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SCIENCE ABSTRACTS

SECTION A.—PHYSICS.

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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

DECEMBER 1919.

GENERAL PHYSICS.

1450. *New Integrating Apparatus.* **H. Naatz.** (Zeits. Vereines Deutsch. Ing. 63. pp. 826–830, Aug. 30, 1919.)—The apparatus here described consists essentially of a rectangular frame, with two straight-edges pivoted at two adjacent corners AB of the frame. A transparent celluloid strip is arranged to slide along the frame parallel to the side AB, and has a central line, with two cross-lines. A full description is given of the method of use, with diagrams and photographs. Theory is also given. A. W.

1451. *A Form of Knudsen's Vacuum Manometer.* **L. F. Richardson.** (Phys. Soc., Proc. 31. pp. 270–277; Disc., 277, Aug., 1919.)—The McLeod gauge has a false zero of pressure if condensible vapours are present. The Knudsen instrument is free from this defect, but has a very limited range. It operates on the principle that when the molecules collide only with the solid parts of the apparatus, then they knock a free vane away from a hotter towards a colder surface. The instrument as originally described by Knudsen could only be kept in operation for a few minutes at a time. The action of the present instrument could be maintained indefinitely. Its range extends up to 20 dynes/cm². The force of the molecular bombardment is balanced by the effect of a magnetic field of special form, acting upon an electric circuit attached to the vane, and the temperature difference is measured by a thermo-junction, the e.m.f. of which is balanced against the same current in a potentiometer. The instrument was constructed by Messrs. C. F. Casella & Co. AUTHOR.

1452. *Single-Deflection Method of Weighing.* **P. H. M. P. Brinton.** (Am. Chem. Soc., J. 41. pp. 1151–1155, Aug., 1919.)—In this method the balance is given a permanent overload on the left arm by screwing the adjusting nut on one end of the beam until when the beam and pans are released the pointer will swing out from 3 to 7 divisions to the right. The pan-arrests must be so adjusted that there is no lateral vibration of the pans when released. Before determining the zero point the stability of the pans is assured by moving the pan-arrest button in and out a few times. The beam is then freed, and the pans are next released by a gentle, steady motion. The pointer will swing out to the right, and the turning-point of this swing is taken as the zero point. To obtain the weight of any object it

excessive. In this case the stress is a maximum at a distance equal to about one-third of the length of the strut from the tapered end. J. W. T. W.

1460. *Angle of Repose of Wet Sand.* **A. G. Webster.** (Nat. Acad. Sci., Proc. 5. pp. 263–265, July, 1919.)—Experiments showed that the limiting slope of a heap of sand depended on the relative amounts of water and sand present. For dry sand the angle was found to be about 33°, but as water was gradually added a certain amount of positive cohesion was shown, the sand remaining in equilibrium vertically and even overhanging. The limit was reached when the proportion of water to sand was about 1 : 5. Beyond this degree of wetness the angle rapidly decreased, dropping to about 20° when the proportion was 7 : 20, and falling still further as more water was added. A. W.

1461. *Surface Tension and Chemical Interaction.* **G. N. Antonoff.** (Phil. Mag. 38. pp. 417–419, Sept., 1919.)—The author has previously [Abs. 132 (1919)] developed a theory of surface tension. In that paper the law of molecular action was selected as the inverse fourth-power law, but it is now shown that the equation given in the previous paper holds whatever law of molecular action is adopted. A. F.

1462. *Reaction of Liquid Jet.* **C. F. Mancini.** (N. Cimento, 16. pp. 81–96, July–Aug., 1918.)—Proof of Mach's proposition that whereas a liquid jet issuing from a vessel exerts a backward reaction upon the vessel, a jet drawn into the vessel by aspiration exerts none. On analysis the vessel in the latter case is found to be subject to two equal and contrary forces. A. D.

1463. *New Form of Catenary.* **J. Hollingworth.** (Phil. Mag. 38. pp. 452–463, Oct., 1919.)—Mathematical treatment of the form assumed by a wire trailing from an aeroplane in flight. **A. R. McLeod.** (*Ibid.* p. 661, Nov., 1919.) **H. G. Plummer.** (Ibid. pp. 732–736, Dec., 1919.) L. H. W.

1464. *Structure of the Atom and the Periodic System.* **T. E. Aurén.** (Nobelinst. Meddel. 5. [Arrhenius Festskrift] (No. 18). pp. 1–7, 1919.)—A theoretical paper in which the conclusions of Kossel [Abs. 641 (1916)] are discussed and the results previously obtained by the author [Abs. 439 (1919)] developed further [compare also Vegard, Abs. 1280 (1917), and Sommerfeld, Abs. 1258 (1918)]. T. H. P.

1465. *Oscillation Phenomena in Physics.* **R. Fürth.** (Phys. Zeits. 20. pp. 303–309, July 1; 332–335, July 15; 350–357, Aug. 1, and pp. 375–381, Aug. 15, 1919.)—Chap. I of this series of mathematical papers deals with the subject from the standpoint of the calculus of probability. Chap. II examines the region of microscopic vision, *i.e.* colloidal phenomena. Here the two cases are treated of statistic equilibrium of a suspension when gravity is taken into account and neglected. Chap. III investigates the molecular domain, and thus deals with thermodynamic statistics. Chap. IV is devoted to the study of the electrical and magnetic states. Chap. V treats the chemical standpoint by examining molecular transformations, while chap. VI deals with atomic changes, *i.e.* radio-activity. Finally, chap. VII discusses radiation.

The author is of opinion that this method will lead to exact knowledge as to the micro-cosmos of matter, electricity, and variation. H. H. Ho.

1466. *Aether and Matter: being Remarks on Inertia, and on Radiation, and on the Possible Structure of Atoms.* **O. J. Lodge.** (Nature, 104. pp. 15–19, Sept. 4, and pp. 82–87, Sept. 25, 1919. Amplified from a discourse delivered at the Royal Inst., Feb., 1919.)

1467. *Quantum Theory and Atomic Structure.* **J. H. Jeans.** (Chem. Soc. J., Trans. 115. pp. 865–871, July, 1919.)—The problem of the structure of matter involves the determination of its constituent parts and of the laws of their interaction. It is now universally accepted that the constituents are electrical, the positive and negative electrons, the latter forming standardised and interchangeable parts of all atoms. Of the former, or "nuclei," less is known. Rutherford has shown that α-particles carry charges $+2e$, where $-e$ is the charge of a negative electron, and that an α-particle and two negative electrons —an electrically neutral system—constitute the normal He-atom, the mass of which is about 7300 times that of a negative electron. The radius is almost exactly 10^{-8} cm. or about 50,000 times that of the negative electron of radius 2×10^{-13} cm. But the scattering of α-particles by matter shows that the α-particles and also the parts of the atoms effective in the deflection are excessively minute compared with the size of the atom, and agrees quantitatively with the assumption that every atom contains only one such infinitesimal nucleus with a charge proportional approximately to the atomic weight of the matter, so that the normal atom consists of N negative electrons each of charge $-e$, and an extremely minute positive nucleus of charge Ne. For helium, $N = 2$, and X-ray spectra experiments show that if the elements are arranged in ascending atomic weight, leaving gaps where the periodic law suggests an undiscovered law, and reversing the order of elements such as nickel and cobalt, or potassium and argon, where demanded by the periodic law, then the "atomic number" N of any element represents its position in this series. Then Moseley and others have shown that the number of negative electrons in the normal uncharged atom is equal to the atomic number N of the element, so that the nucleus charge is $+Ne$. This settles, the author thinks, in the opinion of most physicists, finally and incontrovertibly, the problem of determining the ingredients of the atom. The data from which to determine their arrangement and motions within the atom consists almost entirely of the spectra of the elements, which provide a mass of data admitting of accurate measurement to five or even six significant figures. Knowing the laws of motion, we could determine the spectra, but we cannot deduce the laws from the spectra. But some knowledge of a general kind is obtainable. If, *e.g.*, the nucleus and negative electron of the normal H atom moved according to the ordinary electrostatic inverse square law, the spectrum of H would be continuous, as would be the case for any continuous law of force. Therefore the law must be discontinuous.

In 1901 Planck, starting from a system of laws differing entirely from Newton's, and involving discontinuous motion, obtained a spectral formula agreeing well, probably perfectly, with the observed spectrum of a solid, while Newton's laws do not give such a formula. The result has been universally accepted—as a fact of nature—but his deduction from the assumption of discontinuous motion was objected to. But in 1910 the author showed that Planck's formula was derivable only from a system of laws involving discontinuities, and, moreover, discontinuities substantially of the type assumed by Planck. And a year later Poincaré confirmed and extended these conclusions. The discontinuities cannot be specified completely, but they are of such type that when the electron vibrates isochronously, the *total*

energy of the vibration must fall into "quanta" which are multiples of $h\nu$, where ν is the frequency and h is a universal natural constant. Thus when the energy changes, there must be an instantaneous absorption or emission of one or more quanta of energy. Photoelectric phenomena show what happens to energy so emitted. To ionise an atom by light requires an amount of energy Q, and a frequency above a critical value ν_0, both depending on the nature of the atom. And it is found that $Q = h\nu_0$ (approximately at least), which looks as though light of frequency ν travelled through the ether tied up in some way in bundles of amount $h\nu$. This is Einstein's theory of light-quanta, which must be somewhere near the truth, although probably not expressing the whole truth. It is on these foundations that Bohr has developed his theory. Consistently with it, the electrons may describe elliptic as well as circular orbits, introducing new frequencies calculable by aid of the relativity theory. Sommerfeld has done this for the line Hα, for which there is perfect agreement, qualitative and quantitative, between theory and observation, and Sommerfeld believes that the whole series of frequencies exactly account for the fine structure of the spectral lines. Our definite knowledge of atomic mechanism is practically limited to the few cases in which the atom contains only two constituents. The problem of "three bodies" has not yet been solved in quantum dynamics any more than in gravitational theory. When the whole scheme of quantum mechanism has been unravelled, the problems of valency, stereochemistry, the periodic law, the stability of chemical compounds, their optical and colour properties, and a host of other chemical problems will become the province of the mathematician. G. W. DE T.

1468. *The Impossibility of a Mechanical Model for the Representation of the Relativity Theory.* **J. Petzoldt.** (Deutsch. Phys. Gesell., Verh. 21. pp. 495–500, July 30, 1919.)—The author commences his paper by drawing attention to the time which elapsed before the older established theories such as geometry, theory of functions, etc., received rigid fundamental exposition. He then points out that physicists in their theoretical treatment of electrical processes in moving bodies have come to the conclusion that reduction to mechanical procedure is impossible. The present object is to deal with some objections which Jakob has raised against the author's criticism of Cohen's model. Those objections are answered, and a similar criticism is made of Witte's later model. The author opines the construction of a model, and thereby of a mechanical explanation of the relativity theory, as impossible. **M. Jakob** (*Ibid.* pp. 501–503, July 30, 1919.) H. H. Ho.

1469. *Katabatic Winds at Benson in the Valley of the Upper Thames.* **E. V. Newnham.** (Meteorolog. Office, Professional Notes No. 2. [7 pp.] 1919.)—Benson Observatory (about 200 ft. above M.S.L.) lies in the valley of the Upper Thames 3 or 4 miles WNW. of the crest of the Chiltern Range (800 ft.). In settled fine weather a night breeze from between E. and ESE. often springs up at about 18–20 h. and blows for a few hours' duration. This wind is of a characteristically steady type. Nine excellent examples of the phenomenon were selected from the years 1915–16. The anemograph curves showed such great similarity on these occasions that a mean curve has been calculated. This shows that the normal diurnal curve for velocity is completely interrupted between 18 and 2 h.; the velocity, which commences to rise in the mean curve at the former hour, reaches a maximum of nearly 5 m./sec. at 20 h. 30 m. In one of the individual cases a velocity of

9 m./sec. was reached at 21 h. The wind is of the "katabatic" type, due to the flow of cold air down the slope of the Chiltern Range. The summer months April to Sept. on occasions of clear sky with uniform pressure distribution seem to be particularly suitable for the development of these winds, but on some days which appear well suited the phenomenon does not occur, and thus it is not possible to predict it with complete certainty. J. S. Dr.

1470. *Velocity of the Wind in the Stratosphere.* **J. Rouch.** (Comptes Rendus, 168. pp. 1281–1283, June 23, 1919.)—Observations of pilot balloons made during the war were, under favourable conditions, carried to heights beyond 10 km., that is, into the stratosphere. It has been suggested that the velocity of the wind in the stratosphere falls off very rapidly, but the observations referred to do not support that view. So far as they go they indicate an increase of velocity with height rather than a decrease as the stratosphere is entered. The balloons were assumed to rise at constant rates, as only one theodolite was used for each ascent. Since balloons can only be watched to enter the stratosphere when the sky is clear, and also when the wind is light or moderate at all inferior heights, general conclusions regarding the wind in the stratosphere could not be drawn from such observations. **C. Maurain.** (*Ibid.* 169. pp. 79–82, July 15, 1919.)—The results of J. Rouch are not confirmed by Maurain. He takes the results of 198 balloon ascents made at 30 stations over a period of 8½ years, which are published by the International Commission for Scientific Aeronautics. When averaged, these indicate a gradual increase of mean wind velocity from 5 m./sec. at ground level to 15·5 m./sec. at 11 km., followed by a gradual decrease of wind velocity from that height to the highest level available, 19 km., where the velocity is 8 m./sec. R. C.

1471. *The Gust-measurer.* **R. Seeliger.** (Phys. Zeits. 20. pp. 403–407, Sept. 1, 1919.)—This describes a new portable instrument for measuring the gustiness of wind. It is essentially a pressure-tube anemometer in which the pressure and suction sides are joined together by a continuous tube so that, in use, a current of air is forced through the tube from the pressure opening to the suction opening. The speed (v) of the air in the tube is proportional to the difference of pressure at the two ends of the tube, which is in turn proportional to the square of the velocity (V) of the wind: that is, $v = kV^2$, where k is a constant depending on the dimensions of the tube and the coefficient of viscosity of the air. To measure v, a very thin elastic membrane is placed in the tube and transverse to it. The membrane is fixed to the tube by one edge, and the motion of the opposite edge, due to the flow of air past it, is viewed through a microscope attached to the instrument. Provided the moving edge is properly illuminated, its image in the microscope is seen as a bright line crossing the field of view. If h is the deflection of the free edge of the membrane corresponding with velocity v of the air in the tube, then h, being proportional to the impressed force, varies as v^2, that is, $h = k'v^2 = k^2k'V^4 = KV^4$, where k' and K are constants. k' depends upon the dimensions of the membrane, and is also inversely proportional to its elasticity. Thus the observed deflection h is a measure of the wind velocity, and as there is very little inertia, the motion of the edge shows every variation of the wind without damping or lag. Clearly h increases very rapidly with V, and in order to overcome the difficulty thus introduced a choke is arranged in the tube, controlled by a micrometer screw. In use the screw is turned until the image of the mean position of the edge occupies a definite position

in the field of view. The extent of the oscillations of the edge gives a measure of the gustiness, while the reading of the micrometer screw corresponds with a definite mean wind velocity. Both the micrometer screw and the deflections of the edge are calibrated in a wind channel, so that absolute values of mean velocity and gustiness can be obtained. For a membrane 0·01 mm. in thickness a wind velocity of 2 m./sec. gives a deflection of 0·1 mm. in the instrument described. R. C.

1472. *The Variability of Corresponding Seasons in Different Years.* **F. Stupart.** (Roy. Astron. Soc. Canada, J. 13. pp. 259–263, July–Aug., 1919.)—Winter temperature in Canada is largely dependent upon the relative positions and intensities of the North Pacific "low" and the North American "high" and their associated wind currents. The North Pacific "low" may be affected to a considerable degree by the ocean currents, in particular the Japan current, and it is urged that the time has now come when increased investigation should be devoted to the changes both in position and temperature of these currents. J. S. Di.

1473. *The Travelling Cyclone.* **Rayleigh.** (Phil. Mag. 38. pp. 420–424, Sept., 1919.)—A mathematical determination of the pressure distribution necessary to maintain steady motion in a cyclone, the centre, O, of which travels with uniform velocity over the earth. At the same time the cyclone rotates about this centre with angular velocity ζ; ζ being a function of R, the distance from the centre. In the case where ζ is independent of R, the field of pressure, though circular, is not centred at the point O, but is displaced from it, as has been found by N. Shaw. The case is also treated where $\zeta = Ze^{-R^2/a^2}$, so that the rotation falls off slowly at first, but afterwards with great rapidity. In the treatment the density, ρ, is assumed constant. The death of the author prevented a full consideration of the effect produced by variations of ρ. J. S. Di.

1474. *Terrestrial Angular Velocity.* **E. Oddone.** (Soc. Spettroscop Ital., Mem. 7. pp. 33–42, April–May–June, 1918.)—Revision of Eotvös's determination of the terrestrial angular velocity. Amended expressions for this velocity are given, and certain experimental improvements are suggested. A. D.

1475. *Future of the Transit-Circle.* **J. E. de Vos van Steenwijk.** (Observatory, 42. pp. 334–337, Sept., 1919.)—Much of the work once allocated to the transit-circle is completed or transferred to other instruments (*e.g.* Zenith telescope), but the author suggests various directions in which the transit-circle will still be the best instrument to employ. He summarises thus: (1) The observing of fundamental stars ought to be left entirely to a few of the greatest observatories. (2) Experiments should be instituted to ascertain whether a repetition and extension of the A.G. zones could be effected with the aid of photography, while the intermediate stars of the Astrographic catalogue might be used as reference stars. (3) In view of the preceding, meridian work on secondary stars should be restricted to the needs of the moment. (4) A Durchmusterung for parallax by meridian observers has not yet lost its importance. (5) Meridian observations should, further, be directed into the channels where photographic research encounters special difficulties, *e.g.* systematic observations of stars of type M that are too sparsely distributed for examination by samples as in the plan of selected areas.

The author points out how poor otherwise are the prospects of the M, N, and O stars, whose red colour discounts their being dealt with by photography. W. W. B.

1476. *Problem of Island Universes.* **H. Macpherson.** (Observatory, 42. pp. 329–334, Sept., 1919.)—This is a sketch of the various phases through which Thomas Wright's theory has passed from the time of Kant and Herschel up to the recent work of Hertzsprung and Shapley. Of three possible theories in regard to spiral nebulæ, (1) that they are nebulous and within the galactic system, (2) that they are appendages of the system, as distant as globular clusters, and (3) that they are "island universes," the author considers the first highly improbable, and is not so strongly drawn to the second as Shapley, since he thinks they ought to be resolvable at such distances. If, as has been computed, their brightest stars are fainter than 21st magnitude they must either be all dwarfs, or at such immense distances as to be "island universes." No definite conclusion is yet reached. W. W. B.

1477. *Distribution of Aphelia in Solar System.* **C. D. Perrine.** (Nat. Acad. Sci., Proc. 5. pp. 371–377, Sept., 1919.)—In binary systems orbital eccentricity appears to depend on relative masses, so the author has been examining the aphelia of the secondary bodies of the solar system, to see whether these exhibit any preference, and gives a *résumé* of his results.

If there is any preference as suggested, the larger eccentricities must either be associated with larger relative mass, or with smaller. In the latter case, which is the one commonly found, capture is naturally suggested as the explanation. The present results deal separately with major planets, minor planets, short-period comets, and parabolic or long-period comets. All except the last are closely associated with the ecliptic plane. The aphelia of the major planets are in the half of the sky centred in longitude about the apex of the solar motion, thus the centre of preference in direction is that of the intersection of the ecliptic with the galactic plane. The aphelia of the minor planets show a marked preference for longitude 195°, as also do those of the 45 short-period comets. The long-period or parabolic comets show partial preference for the longitude of the apex of solar motion, 90°, but more marked for that of the anti-apex at 270°, with a slight preference for the ecliptic plane. The short-period comets are presumed captures by the action of the large planets, but they agree better with the minor planets. The author outlines a hypothesis which may account for the position of the axis of preference with regard to the ecliptic and the galactic plane. The idea is that the two star-streams may be portions of one curved stream, and the axis of preference a tangent to this stream. The centres of preference of the parabolic comets are both 10° or 15° to the south of the ecliptic; and this, in the author's view, is in favour of the theory that the planets were captured from a passing stream. He considers, however, that the hypothesis he advances is too speculative for present discussion. W. W. B.

1478. *Moon in Daylight.* **J. Evershed.** (Observatory, 42. pp. 339–341, Sept., 1919.)—The author has experimented with various substances, in order to test the true colour and reflective power of the moon, with and without a yellow screen. Finely-ground aluminium held in sunlight gives, he thinks, the closest approach to the darker parts of the moon, and finely-ground glass to the brighter parts, but the moon seems whiter than the glass. With yellow screen his experiments suggest rocks of blue-grey shade with white patches.

The moon looks yellowish when reflected at night from a silvered lens. He thinks a new determination should be made of the colour index, from the star-like image reflected from an unsilvered lens. [See Abs. 30 and 763 (1916).]
W. W. B.

1479. *Recent Simultaneous Measurements of the Solar Constant of Radiation at Mount Wilson, California and Calama, Chile.* **C. G. Abbot.** (Nat. Acad. Sci., Proc. 5. pp. 383–386, Sept., 1919.)—It is concluded that the spectrobolometric determinations of the solar constant of radiation made at Mount Wilson and Calama [see Abs. 26 (1919)] mutually support one another and indicate a variability of the solar radiation. Since the two stations are situated in different hemispheres of the earth, separated by a distance of upwards of 5000 miles, the result strongly confirms the authors' view of the short-period variability of the sun. L. H. W.

1480. *Irregular Variations of the Moon's Longitude and their Origin.* **A. Einstein** and **A. v. Brunn.** (Preuss. Akad. Wiss. Berlin, Ber. 22. pp. 433–436, and 28. pp. 710–711, 1919.)—Einstein attempts to ascribe the irregular periodic variations of the moon's longitude, obtained as unexplained residuals from lunar theory, to the periodic alteration of the earth's moment of inertia with respect to the latter's axis of rotation ; such alteration being due to the lunar tide. A. v. Brunn, in the second communication, points out that Einstein's explanation is based upon the latter's erroneous conception regarding the method of time-determination used in astronomy. This error is admitted by Einstein in a footnote. L. H. W.

1481. *Secular Acceleration of Moon's Longitude from Modern Observations.* **E. W. Brown.** (Roy. Soc., Proc. 96. pp. 69–70, Aug. 1, 1919.)—This is a criticism of a paper by Nevill [see Abs. 546 (1919)] in which it was argued that no change in the secular acceleration was shown from 1640 to 1915. It is now pointed out that the residuals are not small unsystematic quantities, but are of a periodic character, and that a periodic term whose period is approximately equal to the length of the series of observations considered will naturally show no cumulative effect at the end of such period. A numerical case in point is given, and the author concludes by challenging Nevill's statement as to the cause of the large outstanding fluctuations, since the work of the present author, and of Radau and Newcomb, points to the opposite conclusion. W. W. B.

1482. *Rotation of Inner Planets by Spectroscopic Method.* **L. Rodés.** (Observatory, 42. pp. 308–315, Aug., 1919.)—The difficulty of deciding between the short and long rotation periods of Venus and Mercury has induced the author to investigate the path of rays from Sun-planet-earth for various aspects and conditions, dividing the reflecting surface of the planet according as it is approaching or receding. He considers various causes of dissymmetry in the resulting spectral lines, especially imperfect guiding, and concludes that for the inner planets the value of the observation is weakened by the facts (1) that they cannot be observed for this purpose when full, which makes the effect to be measured less, and the defect due to uneven guiding more ; (2) that the inclination cannot be properly eliminated as the equator is not exactly known, and that, the image being small, there is much greater uncertainty in the measures. Some of these drawbacks apply equally to Neptune and to a less extent to Uranus. The author considers it

very doubtful whether a rotation of Venus of about the same rate as that of the earth could be definitely measured, but that approximate values could be obtained at the most favourable positions, 55° and 305°, the residuals being towards violet when the planet is E. of the sun, and towards red when it is W. W. W. B.

1483. *Spiral Nebulæ.* **C. L. Charlier.** (Comptes Rendus, 169. pp. 430–431, Sept. 1, 1919.)—Facts which must fit into any hypothesis regarding spiral nebulæ, are that they avoid the galactic condensation and favour the galactic polar regions, and that their velocities as determined by the spectroscope are very great (hundreds of km. per sec.), and nearly all receding from the solar system. The author suggests that outside bodies coming into collision with the galactic condensation, if of small velocity, would be captured by it, especially if moving nearly parallel to the galactic plane. If, however, their velocity be great, they would rapidly recede, probably carrying off some part of the system, which would form a spiral nebulæ. This would fit the facts as above stated. The Andromeda nebula and others which are approaching the galaxy fall into the class of nearly parallel motion. W. W. B.

1484. *Observation of Kopff's Periodic Comet and of Metcalf's Comet, 1919b. at Besançon.* **P. Chofardet.** (Comptes Rendus, 169. pp. 382–383, Aug. 25, 1919.)—Kopff's comet is noted as being round, with a brighter nucleus, and of about 11th magnitude. Metcalf's comet of 9th magnitude, without a tail. The observations of the first were from Aug. 16 to 22, of the second on Aug. 23. W. W. B.

1485. *Light-Curves of Variable Stars.* **P. Guthnick.** (Astron. Nachr., No. 4993. Observatory, 42. pp. 352–353, Sept., 1919. Abstract.)—An account of experiments with a rotating ebony sphere, first, unevenly polished, and next unevenly whitened with chalk, viewed under a phase angle of 14½°, and electric illumination. The experimenter concludes that it is possible to reproduce in this way typical light-curves of the Cepheid types, and of those of Mira Ceti, R Sagittæ, η Geminorum and similar stars. Thus the variability of these types could be explained on the hypothesis of a rotating sphere with an irregular distribution of surface brightness, generally not constant, and with a more or less absorbing atmosphere. This last point he studied by having the electric illumination out of focus. W. W. B.

1486. *Bright Bands in Nova Spectra.* **W. S. Adams** and **Joy.** (Astron. Soc. of Pacific, Publ., June, 1919. Observatory, 42. p. 352, Sept., 1919. Abstract.)—Nova Aquilæ III, observed this spring, repeats in its bright bands two features already noticed for Nova Geminorum II and Nova Persei. The bands remain of the same complex structure (the detailed displacements varying directly as the wave-length) as that of the H lines months previously when the star just settled down from the initial outburst. Also the structure is the same for different elements: H, Nb, and He. The structure of these bands differs for different novæ, but seems to be stable for each separately. W. W. B.

1487. *Physical Interpretation of Albedo.* II. *Saturn's Rings.* **L. Bell.** (Astrophys. J. 50. pp. 1–22, July, 1919.)—The general character of the rings has been settled by Maxwell's dynamical investigation and Kepler's spectroscopic study, but details of structure are still indefinite. The present paper

attacks them from the point of view of reflecting power. The general albedo of Saturn is stated to be 0·63, and of the brighter equatorial belt 0·75, the outer part of the B-ring is brighter still, the inner edge rather less bright, the A-ring distinctly fainter, while the C-ring was only a few hundredths of the brightness of B. The range of albedo of the rings is therefore very wide, from that of very bright cloud nearly down to that of black paper. The matter of the rings has to be compared with finely-divided matter, and the effect of the fineness of the division and of the closeness of the packing is considered. Tables are given of the reflection coefficients of some white substances ranging from 89·4 for magnesium carbonate to 65·0 for cloud; and another of rocks, from 0·51 for pumice to 0·078 for grey syenite. It appears that no terrestrial substance in mass can give so high a brilliancy as the bright part of the B-ring. Optical dust very finely-divided is necessary, and monochromatic photographs indicate that this is also the case with the C-ring, though the packing there is less dense. The ring structure is not invariable, but the condensations noted by several observers when the ring is seen edgeways, agree with the impression of a heaping up of scattered dust. Various experiments on the *minimum visible* point to a thickness not exceeding 15 km. for the rings. After some discussion of observations by Barnard, Ainslie and others, the author concludes that the albedos and light-transmission coefficients preclude the possibility of any part of the rings being of satellite dimensions, but thinks the substance must range "from a few metres in diameter down to brickbats, chips and dust, the last-named being the most plentiful in the bright zones of rings A and B, when it appears to have its continuous origin in an increased volume-density of the larger masses." He computes the total mass of the rings as hardly exceeding 1/100,000, and probably much less. The dust-cloud appears only on the shadowed side of the rings, so the author considers that when the sun rises above the plane of the ring it drives the dust down on to the bright surface. His general view of the system of rings is "a substantially plane, very thin stratum of bodies of meteoric size, swept permanently clear at Cassini's division, thinned and grooved elsewhere by the perturbations of the satellites, denser near the grinding zones of action, and thinning out away from them. Permeating and overlaying this is a loose body of widely-scattered dust, more and more tenuous away from the ring-plane, and everywhere away from it so thin a cloud that it reflects no visible light save when seen in great thickness edgewise." He considers that the pressure of radiation keeps this fine dust in a state of perpetual motion. W. W. B.

1488. *Spectral Series and the Grouping of Asteroids.* **F. E. Kester** and **D. Alter.** (Astrophys. J. 50. pp. 50–55, July, 1919.)—The authors have tabulated the asteroids according to the mean daily motion of the radius vector in seconds of arc, and constructed a figure with lines for each of these values, having length proportional to the number of asteroids having such value. The "commensurable" points are clear, and there are several regions of concentration. The idea is to find some analogy between these and a spectral series of Rydberg's form. A fair accordance is found with the simple Balmer series, with $p = 2$, and a closer accordance is found with $p = 2{\cdot}041$. There is a suggestion of evidence that the inverse-square law holds for inter-atomic distances. The analogy is not claimed to be very close between the asteroids and the atoms, but various reasons are given, notably the enormous orbital frequency of the atomic motions as compared with those of the asteroids, why this could not be expected.

It is an admitted difficulty that owing to perturbations for which Jupiter is chiefly responsible, the mean motions of asteroids are continually varying.
W. W. B.

1489. *Colours and Magnitudes in Stellar Clusters.* XIII. *The Galactic Planes in* 41 *Globular Clusters.* **H. Shapley** and **M. B. Shapley.** (Mt. Wilson Solar Observat., Contrib. No. 160. Astrophys. J. 50. pp. 42–49, July, 1919.)—Counts on large-scale photographs agree with counts on Franklin-Adams charts, so that the latter can be used for detecting ellipticity in clusters. Of 41 clusters investigated 30 show an apparent elongation in the nature of a disc shape; others appear circular, but this may be due to perspective. Messier 19 is probably the most elongated cluster, having stars twice as numerous in position angles 15° and 195° as in directions perpendicular to the major axis of the projected ellipse. Globular clusters are much less flattened than spiral nebulæ or what appears to be the general galactic system. Messier 22, the globular cluster nearest the galactic plane, appears to have its main plane parallel to the galactic plane, and this appears to be an example of a general rule that the closer the cluster to the galactic plane, the more nearly is its main plane parallel. [See Abs. 34 and 269 (1919).]
W. W. B.

1490. *Change of Period of δ Cephei.* **A. S. Eddington.** (Observatory, 42. pp. 338–339, Sept., 1919.) — Hertzsprung's table of observations of δ Cephei, put in as evidence of a gradual shortening of its period, is inconclusive, as its chief point depends upon observations in 1785. In any case the change shown is too small to confirm the contraction theory of a star's energy. The writer cannot avoid the conclusion that the star's energy does not come from contraction. W. W. B.

1491. *Some Stars with more than Half a Second of Annual Proper Motion.* **E. Cosserat.** (Comptes Rendus, 169. pp. 414–418, Sept. 1, 1919.) — The Toulouse Astrographic zone contains several stars of large P.M. and, pending a more complete discussion, places and P.M.'s are given here for seven of these in the first nine hours of R.A., four of the seven forming two pairs of stars. The largest P.M. in the list is that of van Maanen's star, first noted in 1917, having a motion exceeding 3 seconds annually. Barnard's P.M. star also falls in the Toulouse zone, but is reserved for a future communication.
W. W. B.

1492. *Notes on Stellar Classification.* **N. Lockyer.** (Nature, 103. pp. 484–486, Aug. 21, 1919.)—In continuation of previous work on spectra of 471 brighter stars classified at South Kensington, and 354 stars classified at Sidmouth, a further 287 stars from more recent work at Sidmouth give a third temperature curve, the two previous ones being reproduced for comparison. The similarity is striking, though in the case of the brighter stars the temperature peak falls later. The Harvard classification of the stars in the two Sidmouth sets is tabulated for comparison, as these two sets were all obtained by the same three observers with the same instrument. The author discusses the features of the curves, and shows how they can be made to test his evolution hypothesis; he asks for tens of thousands more for this purpose. W. W. B.

LIGHT.

1493. *Uniformity and System in the Construction of Telescopic Sights.* **C. Leiss.** (Deut. Jäger-Zeit. 72. p. 141, 1918. Zeits. Instrumentenk., Beib. 11 and 12. p. 55, June, 1919.)—Three types of telescopic sight are proposed, of which the main data are tabulated below. Stress is laid on the importance of brightness of image, and its dependence on size of the exit-pupil. If the exit-pupil is smaller than the eye-pupil, then the cone of rays proceeding from any object point which, after passage through the instrument, would otherwise enter the eye, will have its outer portion stopped out in passage, so that the eye-pupil will not be able to exercise its full light-receiving capacity. The pupil of a normal eye in darkness expands to about 6 mm. diam., which therefore is the minimum diam. the exit-pupil should have to avoid loss of light. Telescopic sights are usually attached to the weapon by clamp and collar supports, hence to facilitate exchange all three types should be made with the same width of body tube. The magnifications suggested are $2\frac{1}{2}$, 5, and 8. The lowest power with large field of view would serve for shooting at fleeing game, the medium power for general purposes, and the power 8 for use in the dusk.

Magnification.	Entrance-pupil.	Exit-pupil.	Light-grasping Power.	Field of View at 100 m.	Distance of Eye.	Length of Telescope.
$2\frac{1}{2}$	20·0	8·0	64	18	8	28
5	0	7·4	54·7	9	7·5	31·5
8	48·0	6·0	36	5·5	7·5	37

A. E.

1494. *Measuring Apparatus for Spectroscopic Work with Röntgen Rays.* **C. Pulfrich.** (Zeits. Instrumentenk. 38. pp. 17–27, Feb., 1919.)—A detailed and illustrated account of the apparatus and the method of using it.

A. E. G.

1495. *Method of Examining the Optical Purity of Quartz Crystals.* **H. Buisson.** (J. de Physique, 8. pp. 25–31, Jan., 1919.)—The experimental arrangement is very simple. A beam of light from a source such as a Cooper-Hewitt vacuum mercury lamp is sent in succession through a diaphragm with a variable aperture, a polarising nicol, a first lens which renders the rays parallel, and a second lens which would bring the rays to a focus. The analysing nicol is placed near to this focus if the nicol is of small section, or between the two lenses if it is large enough not to cut off any of the rays. In the absence of any crystalline plate if the eye is placed at the focus of the second lens, a uniformly illuminated disc is seen, which is extinguished if the nicols are crossed. If now the crystalline plate is introduced between the lenses in front of the analyser, the light reappears,

but the illumination is not uniform and the imperfections of the crystal become visible. If monochromatic light is employed, a screen being used, any irregularities in the crystal are strikingly shown by fringes which show the shape of the irregularity. The method is useful, since no accurate cutting or polishing of the crystal is necessary. Photographs of typical cases observed are reproduced. A. W.

1496. *Immersion Method for Determining the Refractive Index of Solid Bodies.* **C. Fabry.** (J. de Physique, 8. pp. 11–25, Jan., 1919.)—The refractive indices of solid bodies can be measured with an accuracy reaching the fifth decimal place, by means of an immersion method which consists in preparing a liquid mixture having an index near that of the solid. Absolute equality between the refractive index of the liquid and that of the solid is not sought. A slight deviation is consequently produced in the ray passing through the solid, and this effect is measured. At the same time the index of the liquid is measured by the deviation given by a reference prism, of refractive index near to that of the liquid, also immersed in the liquid. Repeating these operations several times for different compositions of the liquid, a series of readings is obtained from which the index of the solid can be calculated by interpolation. The measurements are differential with respect to the reference prism, and the method only requires the measurement of small angles. A series of reference prisms is necessary. The method is applied to transparent substances of different shape, including lenses, irregular bodies with curved faces, prisms with faces polished or unpolished, and large-grained powders. The method has the advantage of allowing determinations of the refractive index to be made for bodies whose form it is not desired to alter, or for specimens of rough glass, no careful cutting or polishing being necessary. A. W.

1497. *Molecular Theory of Refraction, Reflection and Extinction.* **L. Natanson.** (Phil. Mag. 38. pp. 269–288, Sept., 1919.)—Treats on the electromagnetic theory the propagation of homogeneous radiation through a material medium, that is, through space in which a collection of very minute, equal, simple linear vibrators are distributed at random. The author acknowledges indebtedness to Rayleigh's treatment of the scattering of light. [See Abs. 670 and 1230 (1916).] E. H. B.

1498. *Michelson's Experiment.* **A. Righi.** (Accad. Sci. Bologna, Mem. 6. pp. 37–54, 1918–1919. Comptes Rendus, 168. pp. 837–842, April 28, 1919. N. Cimento, 16. pp. 213–242, Nov.-Dec., 1918.)—First part of a revision of Michelson's arguments, in which it is shown that, on Huyghens' principle, instead of a displacement of fringes between the case in which the terrestrial motion is parallel to the incident light and the case in which that motion is transversal to the same, we should—if the angle between the two mirrors be exactly 90° and the film be inclined at exactly 45° to them—have no change in the phenomena of interference. This result—the invariability of the optical effect under a rotation of 90°—is general, whatever be the initial orientation. This does not necessarily vitiate the conclusions as to longitudinal contractions or the theory of relativity. A. D.

1499. *Syntonic Hypothesis of Colour Vision with Mechanical Illustrations.* **E. H. Barton** and **H. M. Browning.** (Phil. Mag. 38. pp. 338–348, Sept., 1919.)—The hypothesis here advanced is that each element of the retina may

possess syntonic vibrators of frequencies corresponding to those of red, green, and violet light respectively. These responders are supposed to be of molecular, atomic, or electronic nature somewhat like the resonators of Planck. The adequacy of three such responders to yield the great variety of effects corresponding to those of visual experience is tested by an experimental arrangement. This consists of a horizontal cord from which hang three light pendulums. These are sympathetically stimulated by one or more heavy pendulums hung from the same or an associated cord. The light pendulums represent the vibrators supposed present in the eye. The slight displacements of the cord from which they hang represent the light incident upon the eye. The heavy pendulums which produce these displacements are like the luminous sources.

In order that a vibration of any frequency throughout the range corresponding to the visible spectrum should appreciably stimulate these responders, their "resonance" must not be too sharp. The responders must accordingly have considerable damping. To account for the persistence of vision and some sluggishness in its inception it is further supposed that the responders in the eye do not act directly on the nerves. On the contrary it is imagined that they only start some physiological change which lasts about a tenth of a second. And this change, in its turn, is supposed to stimulate the nerves.

The behaviour of these three responders under various conditions of stimulus is photographically recorded and compared with the facts of colour vision. It is thus found that on these suppositions red and green would make yellow; blue and yellow would make a pinkish tint, and so on for other facts of normal colour vision.

The cases of colour-blindness would be met by the supposition of the absence of "resonators" of certain frequencies.

No claim is made that the resonators postulated have been proved to exist. The considerations here put forward simply show that if the mechanisms postulated were present, colour vision would be, in the main, as we now find it. E. H. B.

1500. *New Colour Transparency Process for Illustrating Scientific Lectures.* **A. E. Bawtree.** (Phys. Soc., Proc. 31. pp. 235–236, Aug., 1919.)—For astronomical, microscopic, and archæological subjects, and for radiographs and other purely photographic records, monochrome photographic slides leave nothing to be desired, but for many purposes colour is necessary. Owing to the large scale of magnification upon the screen only the crudest washes can be obtained by hand painting. Processes of natural colour photography are excellent when there is no very fine line work which would be destroyed by the grain of the image; but some subjects require definition of microscopic fineness combined with brilliant colouring. In the process now proposed the image is produced in a thin colloid film upon bare glass. A range of dyes and mordants has been selected by which practically any shade of the most brilliant colouring can be obtained. By suitable insulating films, images in any number of colours can be superimposed and accurately registered with one another. Thus, diagrammatic slides can be prepared in various colours. The passage of a beam of white light through a prism can be shown spreading out into bands of colour instead of merely initialled lines. Coloured mosaics can be placed in a diffusing lantern to show the preparation of additive colours, *e.g.* red and green producing yellow, more convincingly and brilliantly than with the Maxwell disc.

The process has other applications than the preparation of lantern slides. If a screen of lines ruled in alternate red and green of, say, 250 lines per inch have projected upon it by means of a lens the image of a screen of similar ruling, but on lines of alternate black and white, the former screen will appear to change colour with a movement of the latter image of only 1/250 in. Thus the smallest movement can be rendered strongly visible to the largest audience. In this manner compressive or tensile strain in a rod or the expansion of a rod with heat can be shown. An experiment demonstrating the laws of fluid friction and of motion is also described. A. E. G.

1501. *Spectral Composition and Colour of High-power Searchlight Arcs.* **I. G. Priest, W. F. Meggers, H. J. McNicholas, K. S. Gibson,** and **E. P. T. Tyndall.** (Phys. Rev. 14. pp. 184–187, Aug., 1919. Abstract of paper read before the Am. Phys. Soc., April, 1919.)—Describes research carried out by the above investigators in co-operation with the Searchlight Investigation Section, Corps of Engineers, U.S.A. Preliminary data on the spectrophotometry of such arcs were obtained by the colour-matching method of rotatory dispersion [Abs. 166 (1913) and 1246 (1918)]. Details are given of the method as applied to a number of searchlight arcs. Some of the values obtained for the spectral distribution are given in tabular form. It is expected that the complete report will be published later in the military reports of the Bureau of Standards. A. W.

1502. *Dispersion and Polychromatism of Polarised Light diffracted by Small Particles.* **M. A. Schirmann.** (Ann. d. Physik, 59. 6. pp. 493–537, Aug. 22, 1919. Akad. Wiss Wien, Ber. 127. 2a. pp. 1559–1628, 1918.)—This very comprehensive paper deals with the problem of the scattering and polarisation of light by particles whose dimensions are of the order of its wave-length. The object of the author is to explain the totality of the phenomena by means of investigations with respect to single particles. Section 2 reviews previous experimental work on the polarisation phenomena of colloidal solutions by Arago, Tyndall, Threlfall, Pernter, Ehrenhaft, Müller, Steubing, and Talbot. Section 3 deals with the objective of the present research, which is briefly to connect the position of the polarisation maximum with the colour phenomena. For all theoretical and experimental investigations the shape of the particle is found to be of fundamental importance for polarisation at single particles. Section 4 examines the theory of polarisation of the diffracted light at small spheres. Section 5 gives the numerical calculation of polarisation at single particles in terms of the wave-length of the incident light and of the particle radius :—(A) *For small metallic spheres.* (*a*) Dispersion of the max. polarisation of the scattered light. (*b*) Comparison of theory with results for aqueous metallic solutions, *e.g.* colloidal gold, and the apparent deviations from the position of max. polarisation of the different average observation values. (*c*) Behaviour of indefinitely small particles. (*d*) Discussion of the percentage content of polarised light and comparison with results for solutions. (*e*) Discussion of the total radiation. (B) *For small dielectric spheres.* (*a*) Dispersion of the max. polarisation and comparison with results for turbid media. (*b*) Discussion of the percentage content of polarised light, and the total radiation. In section 6 the numerical calculation is made of the polychromatism of the polarised light scattered by single particles. In section 7 new optical methods are described for the dimensional determination of the submicroscopic particles of spherical form, based on polarisation effects. Consideration of the wave-length of the incident beam as variable shows that the diffracted light is not only strongly

polarised in a manner varying with the angle of incidence, but that the position of the polarisation maximum is itself a function of the wave-length. The character of this function is determined by the particle, and the present investigation shows that the polarisation maxima or minima for definite particle dimensions and different wave-lengths are situated so that the angle for max. polarisation of the components oscillating perpendicular to and in the vision plane is inversely proportional to the corresponding wave-length for metallic spheres, and directly for dielectric spheres. Consideration of the particle radius as variable shows, for incident monochromatic light for different materials, a dependence of max. polarisation upon particle dimensions. By combining the displacements of the maximum due to the above causes for incident white light, the colour of the scattered light is determined. By growth of the angle occurs a gradual transition from longer waves of weaker intensity to shorter waves of stronger intensity whereby the emitted colours are not pure spectrum colours but mixtures. The investigation has proved that the polychromatic character of the scattered polarised light is a phenomenon which is connected with the spherical shape of the polarising particle and can be traced to the dispersion of the diffracted polarised light. Agreement has been found between the theoretical polarisation results for the dielectric deduced from the extended polarisation formula and the observations on turbid media made by Arago, Tyndall, Pernter, and Ehrenhaft. The lack of agreement concerning the position of the polarisation maximum in aqueous metallic solution has been completely explained on the dispersion theory by taking into account the particle dimensions and the composition of the incident light. Section 9 includes a table of data for gold.

Numerous curves and tables are contained in the paper. H. H. Ho.

1503. *Excitation of Spectral Lines.* **R. Seeliger.** (Ann. d. Physik, 59. 7. pp. 613–634, Sept. 4, 1919.)—This paper presents data from various sources relative to the question of the emission of spectral lines by atoms or by molecules, and also deals particularly with the case of excitation by electronic impact, a discussion being given of the dependence of the intensity of the emitted line on the velocity of the electron. A function is introduced, to which the name "excitation function" is given. This function is the product of two factors, one of these being the mean energy emitted in impacts causing spectral excitation, the other depending on a certain impact parameter. The use of this excitation function in discussing experimental results, and in reference to the quantum theory, is dealt with at some length. A. W.

1504. *Einstein-Effect in the Gravitation Field of the Sun.* **L. Grebe** and **A. Bachem.** (Deutsch. Phys. Gesell., Verh. 21. pp. 454–464, July 30, 1919.)—Einstein's theory of relativity [Abs. 853 (1916)] requires that there should be a shift of spectral lines excited in the gravitation field of the sun, towards the red end of the spectrum. The results of the research here described show a shift towards the red of the nitrogen band λ3883. The amount of this shift is different for the different lines of this band, but is generally below the magnitude of the Einstein-effect. The results cannot be explained as being due to the existence of higher pressures in the sun, since, in agreement with earlier measurements, the position of the nitrogen band was found to be independent of the pressure. Vertical currents in the sun are also out of the question, since the shift at the edge of the sun and that at the centre show no difference. It is shown that, owing to unsymmetrical structure, a spectral line may exhibit an apparent difference in position for

the absorption as against the emission spectrum. On this account fortuitous shifts of lines with small dissymmetry may be observed, and such an effect would give rise to corresponding irregularities in the values observed for a number of lines uniformly shifted by some other cause. Measurements of the nitrogen band lines show that a predominating dissymmetry probably exists towards the shorter wave-lengths. The existence of this dissymmetry has a tendency to reduce the displacement effect (towards the red) in question, so that on the whole the corrections to be applied have the effect of increasing the observed displacements. If this is carried out, a displacement effect results, which agrees fairly well with the value predicted by Einstein, so that the existence of the Einstein-effect is highly probable. A. W.

1505. *Emission Spectra and Atomic Structure.* **J. W. Nicholson.** (Chem. Soc. J., Trans. 115. pp. 855–864, July, 1919.)—After remarking that Soddy's views [Abs. 446 (1919)] cannot be seriously contested by either physicist or mathematician, the author insists on the necessity of chemical and physical co-operation in the investigation of atomic structure. He here considers only an ideal simplification of existing spectra which can be illustrated or even confirmed from the lighter and simpler elements, to which, however, theories of atomic structure must conform. Spectral series are therefore here regarded as consisting of three mutually related sets: (1) diffuse, (2) sharp, and (3) principal series, the extreme of any one of which implies that of the other two. The lines in any one series may be single, double, or triple, and an element may emit two or more such distinct sets. As the lines in any series approach closer—towards the violet—the lines cease, in the laboratory, to be visible, and the limit, identical for (1) and (2), must be calculated, giving the wave-number intervals for the principal series, for which the Rydberg-Schuster law gives the limit. This interval—the number of wave-lengths in 1 cm.—between two members of a doublet—remains constant for (1) and (2), the two members forming separate series with different limits; but for (3) there is a common limit, the doublets becoming narrower. If we exclude the hypothesis of a nuclear origin of series spectra—and we have no means of experimentally testing any speculative theory of such type, which moreover seems excluded by Zeeman and Stark effects, etc.—the infinity of lines would imply an infinite number of degrees of freedom in the atom, if the spectra are in any sense dynamical vibrations of the atom. Hence we are driven to the assumption of an infinite number of atomic states, as in the theories of Ritz and Bohr. Again, a satisfactory theory of spectra as atomic vibrations must lead to equations giving the frequency direct, instead of its square. The only known case of this is when the atomic vibrations are considered as mainly magnetic, as in Ritz's theory, implying the *magneton*. These theories were extraordinarily successful, but lead to difficulties, of which some are mentioned below: (1) Experiments in the scattering of α- and β-particles by atoms indicate that the usual laws of electrical action remain valid inside the atom. This precludes comparable magnetic forces. (2) Separate rings of electrons are impossible if (1) be true, and this would mean that X-radiation is entirely nuclear. (3) The accepted nuclear dimensions are not consistent with (2). They are also not consistent with its capability of emitting β-particles during radioactive changes. A long list of such contradictions might be given, and the quantum theory gives but little aid.

The author in his own work started with Rutherford's results that the nucleus is at least as small as an electron, and that the law of force between

electric charges is that of the inverse square, to an extreme order of approximation. He then determined the frequencies of dynamical vibration for an atom with one ring containing one to six electrons and a nucleus of defined strength. These are pure numbers except for certain defined vibrations in which the vibrations of the nucleus involve small corrections. He then found that the coronal spectrum, consisting of 36 lines—not yet obtained in the laboratory—fits into the scheme for nuclei 5*e* or 7*e* with 5 or 7 electrons, linking up the whole coronal spectrum as the superposition of the spectra of two elements represented by simple formulæ. The corresponding lines observed in the nebulæ, in addition to those of H and He, are attributed to a hypothetical element *nebulium* with atomic numbers 2, 4, 6. The angular momenta of all these atoms (*nebulium* and *coronium*) are found to be simple multiples of a common unit. Given this result, the spectrum of any one of the five elements can be calculated from that of any other, and the author has suggested that this was the real basis of the quantum theory, and that the angular momenta of the electrons in all atoms were related in this simple way to a universal natural constant, which, being an angular momentum, had the proper dimensions, and even the proper numerical values, of Planck's unit. Bohr has adopted this generalisation in his theory. The *nebulium* and *coronium* spectra are band, not line spectra, and Merton is now seeking to reproduce them by submitting a gas of extreme tenuity to electric force insufficient to ionise it and so detach an electron, but sufficient to show a dynamical vibration spectrum after an exposure of many hours.

The author points out that no model of the H-atom can be considered satisfactory which fails to account for the so-called secondary Balmer series, now known to be a principal, and not a diffuse series, and gives only the six lines obtainable in the laboratory. He considers the origin of this series to be the key to the problem of atomic structure, in that it is known to be due in the main to the H-atom, and not to the molecule. Moreover, an atom is not satisfactory unless it also forms molecules the spectra of which are deducible from that of the atom, and no present model of the H-atom appears to have succeeded in this. G. W. DE T.

1506. *Intensity Decrement in the Balmer Series.* **T. R. Merton** and **J. W. Nicholson.** (Roy. Soc., Proc. 96. pp. 112–119, Sept. 4, 1919.)—Liveing and Dewar have found that in a mixture of the more volatile gases of the atmosphere, consisting mainly of neon and helium and containing hydrogen, the Balmer series could be traced as far as the ninth member. The authors have recently found that similar results can be obtained in helium containing hydrogen at pressures so great that, on certain theoretical considerations, it would seem impossible that the radiations of the higher members of the Balmer series should be detected. These theoretical considerations are consequences of Bohr's theory, which requires the space occupied by a hydrogen atom, in the process of emitting lines of the higher members of the Balmer series, to be such that these radiations cannot be expected to be visible except under conditions of extremely low pressure. With vacuum tubes of the H type filled with pure helium at a pressure of 41 mm. of mercury, hydrogen from the electrodes also being present, it was found possible to observe 12 members of the Balmer series. The lines were surprisingly sharp, and though the twelfth member was very faint, there was no doubt of its presence. Quantitative measurements of the intensity distribution in the Balmer series lines were made, both with these high-pressure tubes and with tubes containing (*a*) water-vapour, (*b*) pure

hydrogen at a pressure less than 1 mm. of mercury, and (*c*) helium with hydrogen at a pressure less than 1 mm. The water-vapour tube was connected to a small bulb containing a few pieces of anhydrous calcium chloride and soda lime, and was sealed off at a pressure of about 7 mm. of mercury. The method of determining the intensities was the neutral-tinted wedge method previously described [Abs. 678 and 1037 (1916)]. The following table summarises the results obtained, an arbitrary intensity of 100 being assigned to H_α :—

λ	A. Water-vapour.	B. Pure Hydrogen.	C. Hydrogen and Helium. Pressure < 1 mm	D. Trace of Hydrogen in Helium. Pressure 41 mm.
H_α	100	100	100	100
H_β	22·9	42·4	60·3	31·8
H_γ	5·78	17·0	13·7	6·80
H_δ	1·06	3·90	2·42	1·03
H_ε	just visible	1·17	—	0·184

These results are discussed. By comparison of the results for B and D, it is seen that in helium at the high pressure $H\beta$ is reduced roughly in the ratio 3/4, as against 2/5 for H_γ, 1/4 for H_δ, and 2/13 for $H\varepsilon$, showing a progressive reduction of a rapid kind towards the violet end of the spectrum. There is no transfer of energy to the shorter wave-lengths, but an actual transfer in the opposite direction. It therefore seems certain that in the tubes of 41 mm. pressure the observation of the higher members of the series depends on the fact that their low intensity, relative to that in tubes at a lower pressure containing pure hydrogen, is more than compensated for by the fact that they do not suffer the same broadening under these conditions. The transfer of energy to members of lower term-number in water-vapour at 5 to 10 mm. pressure, and in helium at 41 mm. pressure, would appear to accord with the theory of Bohr, which demands the existence, for the production of the higher members, of a considerable number of greatly enlarged atoms, but this would appear to be outweighed by the fact that members of the series having a term-number as high as $m = 14$ are visible at such pressures. It seems probable that assumptions of a far-reaching character will be needed to explain the present results in the light of Bohr's theory. A. W.

1507. *Spectral Series.* **W. M. Hicks.** (Phil. Mag. 38. pp. 301–317, Sept., 1919.)—A continuation of previous work [Abs. 1953 (1913), 217 and 1357 (1917), and 1200 (1919)]. The present paper gives the results of an attempt to determine to within 1 in 100,000 the value of the silver "oun." The value finally deduced is $q = 361{\cdot}7837 \pm 0{\cdot}0038$. It should be noted that, if atomic weights in terms of Ag are determined from the oun, the values are independent of the actual value of N used, provided it can be taken as the same for all elements. They should be calculated, therefore, either with $N = 109675$ if in R.Å., or 109678·6 if in I.Å. and the above value of q used. A. W.

1508. *Value of the Rydberg Constant for Spectral Series.* **W. E. Curtis.** (Roy. Soc., Proc. 96. pp. 147–155, Sept. 4, 1919.)—The results given in a previous paper [Abs. 1831 (1914)] have been modified on account of a slight alteration now found to be necessary in the values of the corrections to

vacuum. A number of formulæ, empirical and theoretical, have been compared, and it is found that a two-constant Rydberg formula is capable of representing the Balmer series satisfactorily, and shows an appreciable superiority in this respect over the theoretical formulæ of both Bohr and Allen. The probable effect upon the determination of N arising from the composite structure of the lines has been investigated, and found to be inappreciable, except in so far as this non-homogeneity renders it somewhat uncertain which type of formula should be employed to represent the observed wave-lengths. The provisional adoption of the value 109678·8 for N is suggested. This is probably sufficiently accurate for present purposes, but could be improved upon if accurate wave-lengths of the individual components of H_α and H_β were available. The calculated wave-lengths of the members of the series down to $m = 37$ are given. These do not differ by more than 0·001 Å.U. from the corresponding values given previously.

A. W.

1509. *Luminescence and Ionisation on Oxidation of Phosphorus Trioxide.* **H. Rinde.** (Ark. Kem. Min. Geol., Stockholm, 7. No. 1. (7). [21 pp.], 1917–1918.)—The most recent investigations indicate that, in all probability, phosphorus trioxide constitutes an intermediate product in the oxidation of phosphorus. The author describes experiments on the luminescence of phosphorus trioxide vapour in mixtures of various gases, mostly carbon dioxide and oxygen, the intensity of the light emitted being measured by a photographic process. Since no luminescence occurs in pure carbon dioxide, the phenomenon is evidently due to an oxidation process. As the proportion of oxygen present increases from 0 to 5 %, the intensity of the luminescence increases to a maximum ; further increase in the oxygen-content of the gas is accompanied by a diminution in the intensity, which remains approximately constant between 50 % and 100 % of oxygen ; this unexpected result may be due to continuous emission of light with low pressures of oxygen and to intermittent emission when the pressure of the oxygen is higher. The results obtained with dry and moist gas indicate that in the former case the oxidation proceeds according to the equation, $P_4O_6 + 2O_2 \longrightarrow 2P_2O_5$, and in the latter according to $P_4O_6 + H_2O + O_2 \longrightarrow X \longrightarrow H_3PO_4$, where X represents an unstable intermediate compound undergoing oxidation, reduction or decomposition into H_3PO_4 and some other compound.

The ionisation accompanying the luminescence of phosphorus trioxide has also been studied. No difference is found between the mobilities for positive and negative ions. Just as with luminescence, no ionisation occurs if the gas passed over the trioxide is perfectly oxygen-free, the presence of 0·5 % of oxygen being sufficient to cause the appearance of both luminescence and ionisation. Calculation on the basis of certain rough approximations shows that only a vanishingly small fraction of all the reacting molecules of the oxide gives rise to ions. When electrodes of copper are used, both luminescence and ionisation cease and the copper becomes covered with a black compound, which appears to be a copper phosphide ; thus the intermediate product formed from the phosphorus trioxide vapour and water-vapour is more prone to react with copper than to undergo oxidation. T. H. P.

1510. *The Magnetic Field and the High-frequency Spectrum of the Elements.* **R[ita] Brunetti.** (N. Cimento, 16. pp. 5–18, July–Aug., 1918.)—First instalment of experimental work, examining the action of a magnetic field upon high-frequency spectra, to find what necessity there may be to introduce

the quantum theory. The ordinary means of spectral analysis, even at high resolving powers, offer no hope of direct observation of the break-up of radiations under the action of a magnetic field if the phenomena to be observed are of the order of Zeeman's effect. With the method of curved crystal faces, the lines split up into doublets differing by 0·008 to 0·011 Å.U. In the characteristic spectra of the elements examined, the magnetic fields, of the value and range of value employed, did not show any qualitative modification. A. D

1511. *Nuclear Charges Calculated for L-Radiation.* **F. Sanford.** (Phys. Rev. 14. pp. 177–178, Aug., 1919. Abstract of paper read before Am. Phys. Soc., April, 1919.)—It has previously been shown that on the assumption that X-rays are emitted by electrons which are revolving in elliptical or circular orbits about positive sub-atoms the central positive charges may be calculated, in the case of K-radiation, from the two equations $\phi = 2{\cdot}882 \times 10^{-12}/\sqrt{(\lambda)}$ and $\phi = 2e(N - b)$. From the measurements of Blake and Duane the value of b is 3·6. In Friman's measurement of the wave-lengths of the L-radiation band for a considerable number of elements [see Abs. 57 (1917)] he has indicated what he regards as corresponding lines in the different spectra. The shortest of these lines for a considerable number of elements is marked γ^3. This line is indicated in the spectra of eleven elements. The central charges for these lines may be calculated from the equation $\phi = e(N - 15{\cdot}4) = 2{\cdot}882 \times 10^{-12}\sqrt{(\lambda)}$.

A table is included in the paper in which the values of λ calculated in this way are shown to be in good accord with Friman's measured wave-lengths. A. B. W.

1512. *Focusing X-ray Spectroscope.* **H. Seemann.** (Ann. d. Physik, 59. 5. pp. 455–464, Aug. 5, 1919.)—The author describes a modification of Debye and Scherrer's method of analysing the crystalline structure of powdered substances by means of X-rays. In his modified method a beam of X-rays converges, by means of a wedge-shaped slit, on a line on the surface of a cylinder and, as it again diverges, falls on a layer of the powdered crystals. The latter are arranged to lie on the surface of the cylinder, subtending an angle of about 20 % at the axis. A photographic film is so disposed on the cylindrical surface as to receive the rays reflected from the powder. The main beam of X-rays, unreflected, passes out of the cylinder after penetrating the powder. It is easily shown by simple geometry, that rays of the same wave-length and order reflected from similar crystal planes will be focused at the same point on the film. A. B. W.

1513. *Visible Radiation from the Antikathode of an X-ray Tube.* **J. E. Lilienfeld.** (Phys. Zeits. 20. pp. 280–282, June 15, 1919.)—The paper describes the spectroscopic examination of the bluish-green light emitted from the antikathode of all X-ray tubes. This visible radiation has nothing in common with the heat radiation from the surface of antikathode. The visible radiation excites the bright green fluorescence on the glass walls of the X-ray tube, and renders luminescent the residual gases. Spectral diagrams are reproduced in illustration. A. B. W.

1514. *The L-series in the Tungsten X-ray Spectrum.* **O. B. Overn.** (Phys. Rev. 14. pp. 137–142, Aug., 1919).

Tungsten X-ray Spectrum, L-series; Wave-lengths.—Dershem's results were verified, for the most part within 1/10 per cent., except in the case of 1·777 ×

10^{-8} cm. which was found to have a wave-length of $1{\cdot}202 \times 10^{-8}$ cm. Six new lines were discovered, four of which may belong to tungsten: 1·236, 1·213, 1·079, and $0{\cdot}793 \times 10^{-8}$ cm. This last line appeared light in contrast to the dark bromine absorption band in which it was located; an explanation of this fact is suggested. Dershem's method was used with a very thin crystal and with very long exposures of the Coolidge tube. Four photographs are reproduced.

Tungsten X-ray Spectrum, L-series; Two Groups of Lines Suggested.—Sixteen lines fall into two groups, each line of one having a wave-length 1·151 times that of the corresponding line of the other.

Molybdenum X-ray Spectrum, K-series.—Three faint lines were measured which may belong to this series, wave-length 0·711, 0·706, and $0{\cdot}629 \times 10^{-8}$ cm.

Bromine X-ray Absorption Band.—Evidence of discontinuity found.

Silver X-ray Absorption Band.—Evidence of discontinuity found.

Thickness of a Soluble Crystal.—Determined by a simple method.

AUTHOR.

RADIO-ACTIVITY.

1515. *Model of Radio-active Atoms.* **T. Terada.** (Phys. Math. Soc. Japan, Proc. 9. pp. 185–195, June, 1919.)—A mathematical discussion of a possible structure of radio-active atoms, particular attention being paid to the structure of the "positive nucleus." A "provisional" working model is proposed and is tested in the light of available experimental data. This trial, though still unsatisfactory, suggests openings for further experiment and theoretical investigation. A. B. W.

1516. *Graphical Method Applicable to Radium Measurements.* **N. E. Dorsey.** (Phys. Rev. 14. p. 173, Aug., 1919. Abstract of paper read before the Am. Phys. Soc., April, 1919.)—In the determination of the radium content of sealed specimens that have not reached equilibrium it is very desirable to ascertain promptly the concordance of each observation with those that have preceded it. A simple graphical method used during several years past at the Bureau of Standards, Washington, is now described. A. B. W.

HEAT.

1517. *Temperature Distribution in Solids during Heating or Cooling.* **E. D. Williamson** and **L. H. Adams.** (Phys. Rev. 14. pp. 99–114, Aug., 1919.)

Temperature Distribution in solids; surface heated at uniform rate. Equations are derived for the following typical shapes: (1) Rectangular parallelopiped. (1*a*) Long rectangular rod. (1*b*) Very thin slab. (2) Cylinder. (2*a*) Long cylindrical rod. (3) Sphere. (4*a*) Cylindrical tube heated only outside. (4*b*) Cylindrical tube heated both inside and outside. (5) Spherical shell heated only outside. Results calculated from these equations are tabulated and in some cases shown graphically. These numerical results may be readily applied to the case of similar solids of any size and diffusivity.

Temperature distribution in solids; surface suddenly cooled or heated. Equations are derived for the following shapes: (1) Rectangular parallelopiped. (1*a*) Long rectangular rod. (1*b*) Very thin slab. (2) Cylinder. 2*a*) Long cylindrical rod. (3) Sphere. The distribution inside a sphere at various instants is computed and also the temperature at the centre of a slab, square bar, cube, long cylinder, and sphere as a function of the time. These numerical results may be readily applied to the case of similar solids of any size and diffusivity.

Thermal diffusivity; method of measurement involving determination of temperature-time relation at the centre of a symmetrical solid whose surface is heated either at a uniform rate or very suddenly. The convenience of this method is pointed out, but practical details are not considered. The equations given are in convenient form for such uses. AUTHORS.

1518. *Comparison of Mercury and Platinum Thermometers.* **F. Hoffmann** and **W. Meissner.** (Zeits. Instrumentenk. 39. pp. 212–224, July, 1919. From the Physikal.-Techn. Reichsanstalt.)—Continuation of previous work [see Abs. 1538 (1912)] taking into account the effect of the elastic deformation of the thermometer glass and the compressibility of mercury. If A_t be the coefficient of expansion of mercury under 1 atmo. pressure at temperature t, and if $A_{t,p}$ be the value of this coefficient under p atmos. for the particular glass concerned, then between 100° and 300° $A_t = 181{\cdot}81 \times 10^{-6} + 3{\cdot}47 \times 10^{-9}t + 3{\cdot}93 \times 10^{-11}t^2 - 0{\cdot}2 \times 10^{-15}t^3$ and between 200° and 500°, $A_{t,p} = B \times (1 - 4{\cdot}7 \times 10^{-9}\,t)\,(p - 1) - 4{\cdot}7 \times 10^{-9}(p - 1)$, where $B = 182{\cdot}22 \times 10^{-6} + 1{\cdot}31 \times 10^{-9}t + 3{\cdot}99 \times 10^{-11}t^2 + 9{\cdot}3 \times 10^{-15}t^3$. A_{100} is taken as $182{\cdot}55 \times 10^{-6}$. The values given by the second formula express the results to within a few tenths per cent. and agree with Harlow's results at 300°.

J. W. T. W.

1519. *Theories of Thermal Transpiration.* **G. D. West.** (Phys. Soc., Proc. 31. pp. 278–288; Disc., 289, Aug., 1919.)—The process of thermal transpiration, or the establishment of a pressure difference between two vessels connected by a capillary tube and at different temperatures, takes place at all gas pressures. The explanation of the phenomena at low pressures is well known and simple. When, however, the mean free path of the molecules is of the order of, or smaller than, the diam. of the tube, the

simple explanation fails and a more elaborate hypothesis is necessary. Reference is made to the work of Reynolds, Sutherland and Knudsen. The two latter investigators have proceeded on different lines, but it is shown how Sutherland's original method of treatment can be employed to calculate a formula which is applicable to all pressures, and which is in approximate agreement with the formulæ given by Knudsen for limited ranges of pressure. It is anticipated that the present paper will be of considerable use in the author's further research. AUTHOR.

1520. *Detection of Invisible Objects by Heat Radiation.* **S. O. Hoffman.** (Phys. Rev. 14. pp. 163–166, Aug., 1919. Abstract of paper read before the Am. Phys. Soc.)—Early in 1918 work was started on the Western Front on the problem of detecting men and other objects at a higher temperature than their background, in the dark, by their thermal radiation. The apparatus consisted of a Hilger thermopile mounted in the focus of a 14-in. (36-cm.) parabolic mirror (silvered on the surface), together with a d'Arsonval galvanometer. Men were detected with ease at 600 ft. (180 m.). A man lying in a depression in the ground at a distance of 400 ft. (120 m.) was detected as soon as the upper part of his face was above ground. Ranging aircraft by thermal radiation was also accomplished. E. H. B.

1521. *Distribution of Energy in Visible Spectrum of Acetylene Flame.* **W. W. Coblentz.** (Phys. Rev. 14. pp. 168–169, Aug., 1919. Abstract of paper read before the Am. Phys. Soc., April, 1919.)—A further discussion [see Abs. 427 and 1205 (1919)] of the differences found in the region 0·4 μ to 0·5 μ between the energy distribution in the cylindrical acetylene flame and in the black body. It is pointed out that the errors of experiment in this region are of the order of 5 to 10 %, and that Nichols and Merritt [Abs. 914 (1910)] found a high emissivity in this region. J. W. T. W.

1522. *Spectral Energy-distribution Curve of Acetylene.* **W. W. Coblentz.** (Frank. Inst., J. 188. pp. 399–401, Sept., 1919.)—Shows that the spectral energy distribution of the acetylene flame can be well represented by that of a black body at a temperature of 2360° to 2370° K. [See Abs. 1026 (1916), 630 (1917) and preceding Abs. J. W. T. W.

1523. *Effect of Carbon Dioxide on Gaseous Explosions.* **W. T. David.** (Engineering, 108. pp. 300–302, Sept. 5, 1919.)—The author wished to determine whether the presence of a gas like CO_2, which absorbs radiations of the kind emitted by exploding gas mixtures, would diminish the large loss of heat by radiation. It is found that there is such an effect, but it is due to the lowering of the temperature developed during the explosion. The experiments were made in a steel cylinder, 30 cm. in diam. and height; in a recess, closed on the cylinder side by a plate of fluorspar, is placed a bolometer; the mean gas temperatures are calculated. The gases used are coal gas mixed with oxygen, with air (the nitrogen mixture of the paper), or with up to 65·3 % of CO_2. The presence of CO_2 greatly reduces the max. pressure developed and the speed of the combustion; in a 15 % gas-air mixture a maximum of 105 lbs./sq. in. was reached in $\frac{1}{20}$ sec.; in the presence of 58·6 % CO_2 the figures were 68 lbs. and $\frac{3}{20}$ sec.; and with 65 % CO_2, 49 lbs. and $\frac{11}{20}$ sec. The effect of dilution with CO_2 is much stronger than that of nitrogen. It is probable that the CO_2 diminishes the rate of combustion so much that a considerable portion of gas remains unburnt at the moment that

the max. pressure is attained. The effects are ascribed to the higher specific heat of CO_2 (than N) and to its high volumetric heat at high temperatures. Though the percentages of CO_2 used were higher than those of internal-combustion engines, it seems advisable to reduce the proportions of the products of combustion in the charge to the minimum possible, especially when working with gas mixtures of moderate strength. The experiments further seem to indicate that the vibratory degrees of freedom of the inert CO_2-molecules absorb energy very rapidly from the freshly-formed molecules which are known to possess at the moment of formation a considerable excess of vibratory energy above the amount they would possess under the equilibrium conditions of the gas temperature. The rate of heat emission is greatest before maximum pressure is obtained and in the early stages of max. pressure, although the mean gas temperature keeps constant throughout this period. H. B.

1524. *The Kinetic Theory of Gases.* **C. del Lungo.** (N. Cimento, 16. pp. 68–80, July–Aug., 1918.)—Puts in a simple and synthetic form the relations of entropy under the statistical method applied to a perfect gas. [See also Abs. 197 (1919).] A. D.

1525. *On the Approximation of the Entropy Formula* $S = -kN\Sigma\omega_i \log \omega_i$. **K. Lichtenecker.** (Deutsch. Phys. Gesell., Verh. 21. pp. 236–239, May 30, 1919.)—In a previous communication [Abs. 608 (1919)] the author has shown that the formula usually employed for the entropy S of N similar elements, $S = -kN\Sigma\omega_i \log \omega_i$, gives an upper limit instead of the exact value of the entropy. The problem therefore arises as to whether the approximation afforded by the above formula is under all circumstances so accurate that the deviation has no practical significance. It is now shown in the paper that on the assumption of a simple accessible distribution, an upper and a lower limit may be obtained for the deviation as given by the usual entropy formula from the true values. Moreover, this deviation decreases to an infinitesimal amount when the number of particles increases to an infinite extent. For a number of particles equal to the molar Loschmidt number the deviation on the distribution assumed remains at about $\frac{1}{2}\%$. H. H. Ho.

1526. *A Theory of Vapours.* **E. Wertheimer.** (Deutsch. Phys. Gesell., Verh. 21. pp. 435–454, July 30, 1919.)—The author here presents the principal results of a vapour theory which has occupied him for a number of years [see Abs. 626 (1911)]. Section 1 deals with the fundamental form of an equation of state, which is as free as possible from hypotheses, namely, $p = f(v) + \chi(v)[T - F(v)]$, and in which only the three variables p, v, and T appear. Section 2 considers the definition of temperature. This is based upon thermal radiation and spectral distribution. Vacuum is taken as the comparison medium with which the substance considered is in thermodynamic equilibrium; the necessary condition for this is that the radiation energy U, divided by the cube of the refractive index n, is equal to U_0 for every frequency, where U_0 is the corresponding energy value for the vacuum. The latter when integrated to get the total vacuum radiation energy gives the Stefan-Boltzmann law, $U_0 = aT^4$. The temperature of any substance is therefore defined by the fourth root of the radiation-density of a completely evacuated space. Section 3 reviews the experimental facts. In section 4 the connection between pressure and radiation energy is investigated. The

results of the research are collected in section 5 under the sub-sections of the saturated state, and unsaturated vapours at constant volume, while a discussion of these results follows in section 6. The radiation energy is found to increase linearly with temperature when the specific volume is constant, while the absorptivity and refractive index are dependent on the specific volume. The Rayleigh-law is found to be not generally applicable for dark radiation. With decreasing specific volume the deviations of the pressure coefficient are found to increase continuously from the ideal value, a result in accordance with experience. The difference between the author's standpoint and that of the kinetic theory is as follows: Temperature on the kinetic theory depends in a simple manner on molecular velocities and mean free paths; on the present theory the translatory velocity of the ponderable (electrically neutral) bodies *in vacuo* has no immediate connection with temperature. Primarily the velocity determines only the frequency and momentum of the impacts, while the temperature itself depends on the energy radiated as a result of the impacts. The practical consequences of this standpoint are briefly discussed.

H. H. Ho.

1527. *Thermodynamics of Water-Vapour.* **G. Eichelberg.** (Zeits. Vereins Deutsch. Ing. 61. pp. 750–753, Sept. 8, 1917.)—The author has obtained, by a graphic method, an equation for the isobars of the specific heat c_p of superheated water vapour. The equation obtained is

$$c_p = c_{p_0} + \frac{C_1 p}{T^4} + \frac{C_2(p + 2 \times 10^4)^{8\cdot2} - C_3}{T^{15}},$$

where $C_1 = 3{\cdot}2 \times 10^4$, $C_2 = 2{\cdot}83 \times 10^{23}$, $C_3 = 1{\cdot}64 \times 10^{36}$, and p is measured in kg./m.^{2}. From this equation we can derive the equations of state for the specific volume, the heat content, and the entropy, as well as the characteristic function ϕ, in which all the magnitudes of the region of superheating are contained. By taking into consideration the corresponding function ϕ' for the liquid, the equations for the region of saturation can be derived. All the equations are in good agreement with the most recent experimental values. The deviations amount throughout to only some thousandth parts, and in no case reach the amount of 1 per cent. A. F.

SOUND.

1528. *Speed of Sound in the Sea.* **Marti.** (Comptes Rendus, 169. pp. 281–282, Aug. 11, 1919.)—The determination described was made in the roadstead of Cherbourg at a depth of about 13 m. Three microphones were arranged in a straight line, the end ones being about 900 m. from the centre one. The positions were accurately determined by theodolites. The sound was produced by an explosion in a line with the microphones but some distance away. The passages of the wave-front past the different microphones were registered by an electric chronograph with smoked paper and tuning-fork trace. The different observations gave very concordant results for the two bases. At the temperature of 14·5° the speed of sound was found to be about 1503·5 m. per sec. in the sea-water whose density was 1·0245 gm. per cm.^{3} when at 14·9°. These values need some slight corrections, and full details with final results are to be published later. E. H. B.

1529. *Combination Tones and Overtones.* **E. Budde.** (Deutsch. Phys. Gesell., Verh. 21. pp. 259–264, May 30, 1919.)—A mathematical treatment of the equations of vibrations due to Helmholtz and in the discussion of which the square of a Fourier series plays a part. [See Abs. 69 (1919).] E. H. B.

1530. *Location of Aircraft by Sound.* **G. W. Stewart.** (Phys. Rev. 14. pp. 166–167, Aug., 1919. Abstract of paper read before the Am. Phys. Soc., April, 1919.)—By the use of a pair of long conical horns as receivers it has been found possible to locate the sound. With receivers 12 ft. apart, the accuracy of locating the wave-front is correct within a few tenths of a degree. With the horns 18 ft. in length and 4·5 ft. diameter of opening, the range under fair night conditions for an aeroplane elevation of 6000 ft. was about three times that of the unaided ear. E. H. B.

1531. *Speed of Sound-Pulses in Pipes.* **A. L. Foley.** (Phys. Rev. 14. pp. 143–151, Aug., 1919.)—The speed of sound-pulses in short tubes placed near a spark source is here measured by a photographic method. An instantaneous photograph was obtained of a sound-pulse, part of which had come through a tube, while another part had come through free air. In this way the effect of short tubes of various sizes was determined when their near ends were from 1 to 5 cm. from the spark. Two photographs are reproduced which show that in some cases the pulse may travel faster through a short tube than in free air, and faster through the smaller of two tubes than through the larger. The speed through a tube was found to depend chiefly on the intensity of the pulse as it entered the tube, and this was true even when the motion of the air as a body was prevented by a thin collodion membrane stretched across one end of the tube. The mean speed was less the longer the tube. The paper includes an historical survey of the work done on the speed of sound in pipes, with a two-page table of results obtained. E. H. B.

1532. *Phono-telemeter.* **H. M. Dadourian.** (Phys. Rev. 14. p. 178, Aug., 1919. Abstract of paper read before the Am. Phys. Soc., April, 1919.)—This paper describes a device for locating the source of a sound-wave from a set of sound-ranging data. This is an arrangement of strings attached to the positions (on a chart or maps) of the stations and of lengths whose differences represent the differences in time of the receipts of the signals at those stations. The position of the gun which emitted the sound can then be located. E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

1533. *Size and Shape of the Electron.* **A. H. Compton.** (Phys. Rev. 14. pp. 20–43, July, 1919.)—The author elaborates further his argument [Abs. 549 and 784 (1918)] that, according to classical dynamics, the theory of scattering of high-frequency radiation demands an electronic radius of from $2{\cdot}3 \times 10^{-10}$ cm. to $2{\cdot}5 \times 10^{-10}$ cm. in place of the accepted value 2×10^{-13} cm. The scattering coefficient for different wave-lengths is here calculated for three types of electron : (1) a rigid spherical shell of electricity incapable of rotation ; (2) a flexible spherical shell; (3) a thin flexible circular ring. All these are found to account satisfactorily for the few data on the magnitude of the scattering coefficient for various wave-lengths; but (1) does not account for the difference between the emergent and the incident scattered radiation, and (3) accounts more accurately than (2) for this difference. It is concluded that the diameter of the electron is comparable in magnitude to the wave-length of the hardest γ-rays, and on the best available data of wave-length and scattering by matter of hard X-rays and γ-rays, the electron radius is estimated as about 2×10^{-10} cm. Evidence is found that the radius is the same in the different elements, and that in order to explain the fact that the incident scattered radiation is less than the emergent radiation, the electron must be subject to rotations as well as translations. G. W. DE T.

1534. *Fermat's Principle.* **S. Marcucci.** (N. Cimento, 16. pp. 243–247, Nov.–Dec., 1918.)—An experimental electrical analogy to Fermat's principle. A. D.

1535. *Charges Produced on Benzine when Forced through Tubes under Pressure.* **D. Holde.** (Deutsch. Phys. Gesell., Verh. 21. pp. 465–473, July 30, 1919.)—The liquid is forced through a fine tube into a vessel which has an appendix attached to a gold-leaf electroscope. Some results of this research are :—(1) The charges produced on the benzine are due to friction on the sides of the tube and not to the waterfall effect. (2) The surrounding air temperature, which varied from 13°—31°, has no marked influence on the charges; the insulation of the benzine depends on the dampness rather than on the temperature of the air. (3) The idea that a rubbed insulator gives up its charge only gradually to a metal touching it is not found to be correct in the case of a liquid insulator. P. E. S.

DISCHARGE AND OSCILLATIONS.

1536. *Constitution of Tungsten.* **H. Baerwald.** (Deutsch. Phys. Gesell., Verh. 21. pp. 474–478, July 30, 1919.)—A description is given of an experimental investigation of the electronic emission from tungsten filaments at high temperatures. A discussion follows as to the bearing of the experimental observations on theories of the constitution of the tungsten atom. A. B. W.

1537. *Influence of Magnetic Field on Ionisation by Collision.* **J. Kohn.** (Deutsch. Phys. Gesell., Verh. 21. pp. 390–420, July 30, 1919.)—A brief summary is given, at the outset, of the work published by earlier investigators on the influence of magnetic fields upon electrical discharges in gases. In particular, reference is made to the work of Earhart, Duane, Townsend

("Ionisation by Collision"), and Greinacher. [Abs. 1096 (1915)]. This historical summary is followed by a description of the author's method of experiment, based mainly on Greinacher's work. As a result of his observations the author concludes that strong magnetic fields have a similar effect to large increases of gas pressure, whilst weak magnetic fields act in the same way as small increases of gas pressure. It is shown that the mean free path of the ions has values which are dependent on the dimensions of the gas chamber. A. B. W.

1538. *Electric Arc Characteristics.* **E. Bräuer.** (Phys. Zeits. 20. pp. 393–396, Sept. 1, 1919.)—The usual arc characteristics (potential–current curves) are obtained with rod electrodes whose dimensions are the same for all current strengths, the effects of current density at the ends of the electrodes not being considered. The results thus obtained are not of much value for comparison purposes, since the heat effects due to the different current densities have great influence on the electric quantities involved. Comparable results for different current strengths can be obtained by forming the arc between large blocks of the electrode material, or by using electrodes whose cross-section is proportional to the current strength. It was found that good results could be obtained if the readings were taken within about a second of the striking of the arc, and the characteristics thus obtained can be employed for any arcs working under corresponding conditions as regards electrode heating. The following table gives the values of a and b (for various arcs) in the formula $ei = ai + b$, where e is potential and i the current.

	a	b
Mercury arc, low pressure	55·6	4
„ „ moderate pressure	95·2	24
„ „ high pressure	125·3	46
Carbon arc, length 2·5 cm.	90	89
„ „ „ 0·4 cm.	56·8	22
Salted Carbon (CaF_2) arc, length 2·5 cm.	42	36
„ „ „ „ „ 0·15 cm.	28	10

Typical characteristic curves are reproduced. A. W.

1539. *Anode Discharges.* **E. Goldstein.** (Deutsch. Phys. Gesell., Verh. 20. pp. 128–158, Oct. 30, 1918.)—Following up some observations of his own in 1876, re-observed by Gouy in 1909, the author now finds that the radiation-field at the anode is far more complex than that at the kathode. The phenomena are exceedingly sensitive, so that out of 700 vacuum-tubes not more than three or four repeated the results identically. Under the influence of a magnetic field the luminescence is distributed in ellipsoids, lamellæ, zig-zags and other singular forms, of which 25 illustrations are given: and in these luminescences shadow-effects can be produced. A. D.

1540. *Light Emission in the Kathode Dark Space and in the Negative Glow.* **R. Seeliger** and **E. Pommerrenig.** (Ann. d. Physik, 59. 7. pp. 589–612, Sept. 4, 1919.)—In order to arrive at any general conclusions relative to the emission of spectral lines in the kathode dark space and in the negative glow it is necessary first to obtain observations not only for a large number

of different gases, but also for all the different partial spectra, bearing in mind Stark's observations on the spectral carriers, and further, the increase of intensity in the negative glow must be followed accurately. Experiments are described with nitrogen, oxygen, hydrogen, and argon. Some mercury lines were also observed. The results obtained are fully described and exhibited graphically, and use is made of them to criticise Holm's theory of the dark space. [See Abs. 485 (1913) and 1092 (1918).] A. W.

1541. *Method of Measuring without Electrodes the Conductivity at Various Points along a Glow Discharge and in Flames.* **B. van der Pol, Jr.** (Phil. Mag. 28. pp. 352–364, Sept., 1919.)—When stationary waves are induced in a pair of parallel wires tuned to the frequency of a generator, the current in this Lecher system will increase till a stage is reached where the energy supply from the exciter is just balanced by the energy dissipation in the wires. The principal part of this dissipation is to be found in the Joulean losses, while the radiation from the Lecher system will in general be very small, due to the currents in opposite parts in the two wires being 180° out of phase. But when at a point in the field between the wires some small body is introduced having a finite conductivity, energy will be dissipated in it as well. Under a constant excitation the current and p.d. will therefore, in this case, only reach a lower final value, and this latter current limit is a measure of the energy dissipation in the substance brought between the Lecher wires. It is, however, not a unique measure for the conductivity σ of the body considered, as is obvious from the consideration that both when $\sigma = 0$ and $\sigma = \infty$ no absorption will take place. Hence a second factor must come in, and this is the alteration in the period caused by the presence of the body in the electric field. The above considerations are equally valid, whether the body brought into the field between the wires is electrically connected to them or whether it is not. The procedure is therefore of value when the absorption in a substance is to be measured where the presence of separate electrodes would either disturb the natural state of affairs (as is often the case with test electrodes in a glow-discharge), or where a strong polarisation at the kathode makes the direct-current electrode measurements complicated or uncertain (as in flames). The mathematical treatment of the subject is considered, and the apparatus employed in the case of glow-discharge is described and illustrated. The results obtained are shown diagrammatically, and it appears that the chief interest lies in the variation of the conductivity found over the striations. With this electrodeless method, the *minima* of conductivity are always observed close to the brightest part of the striations, while on the other hand, with the electrode-cross-current method *maxima* of conductivity are obtained at these points. It is, however, possible, as suggested by H. A. Wilson, that in the electrode-transverse-current method secondary ionisation due to the illumination of the testing electrodes might increase the cross currents at the luminous parts of the striæ. This possible cause of error is of course eliminated in the electrodeless method. Moreover, the results yielded by the latter method are in good agreement with the measurements of the electric force at various parts in the striæ made by J. J. Thomson, with the aid of the pencil of kathode-rays sent at right angles across the axis of the striæ. Here the max. electric force was shown to occur at the bright parts of the striations very near their negative end. Now, if at the pressures used the velocity of the ions is assumed to be proportional to the electric force at the spot, a minimum number of ions, and therefore the minimum conductivity, can be expected to occur at a maximum of electric force ;

hence the agreement. A number of preliminary experiments were made with flames. They were simply brought into the space between the ends of the Lecher wires, and the reduction of the wave-amplitude thus obtained again afforded an indication of the conductivity of different flames, or of different parts of the same flame. In the electrodeless method the uncertainties arising otherwise from the polarisation at the electrodes, and from their electron emission if hot, are obviously again eliminated. By this means another proof is obtained that the increased conductivity of salt-laden flames, as measured with test-electrodes, is not wholly due to the presence of the electrodes, as is sometimes supposed, but is a peculiarity inherent in flames.

A. E. G.

1542. *Oscillations during the Discharge of an Induction Coil.* **E. T. Jones.** (Electrician, 83. pp. 167–169, Aug. 15, and pp. 201–202, Aug. 22, 1919.)—The first part of the paper deals with the discharge of an induction coil through a spark-gap. The discharge at the gap consists of three parts : (1) The initial spark due to the escape of static electricity in the vicinity of the secondary terminals, (2) the secondary current, the initial value being that at the commencement of discharge, flowing through the arc established by (1) as an aperiodic decaying current, (3) an oscillatory current having the period of the system and superposed on (2).

When a condenser is connected to the secondary terminals and the primary current exceeds the minimum to cause sparking, the discharge consists of a series of sparks. The number of sparks per discharge increases with the primary current until a certain value of the latter is reached, when the number of sparks is reduced considerably ; sometimes to one or two. The effect of the condenser is to retard the formation of an arc. The latter only appears if the primary current is five or six times the minimum to cause sparking.

The discharge through hard and soft X-ray tubes has been studied, and oscillograms are given showing the form taken by the oscillations. The quantity of electricity passed during the discharge has been measured for various values of the primary current. The efficiency of the coil is estimated at 50 %, but only a small fraction of this is utilised in providing X-rays.

The inverse current through the X-ray tube at break has been investigated. It was found that this current could be eliminated by increasing the primary current sufficiently. The inverse discharge occurred more readily when the primary capacity was increased from the optimum, or when the interrupter did not work properly. Oscillograms have been taken to illustrate these phenomena.

X-ray pulses were examined by the aid of a spectrum tube, and photographs are given illustrating these experiments. N. W. M.

1543. *Formulæ for Resonance Curves of Damped Vibrations.* **B. van der Pol.** (Electrician, 83. pp. 225–228, Aug. 29, and pp. 251–252, Sept. 5, 1919.)—This paper gives a simplified method of obtaining the formulæ for the resonance curves of coupled circuits under the following conditions : (*a*) The coupling coefficient of the two circuits must be small. (*b*) The square of the logarithmic decrements per complete period must be small in comparison with $4\pi^2$. (*c*) The resonance curve obtained may be used, to find the decrements, only for the part near the resonance. (*d*) The spacing of the separate discharges, and the damping factors must be such that the former damped oscillation has fallen off nearly completely before the next one sets in. This

must be the case in the secondary as well as in the primary. This latter condition is usually not mentioned in text-books. When these conditions and limitations are introduced at an early stage into the analysis, the latter leads in a very simple way to the same results usually obtained only by a more or less general investigation and subsequent simplification of the general results, as in the work of Mackû and Bjerknes. The early introduction of the conditions (*b*) and (*c*) into the analysis, obviates the necessity of solving two simultaneous differential equations, and only a limited amount of integration is necessary to obtain the final result; the evaluation of two definite integrals is all that is required. A brief discussion of the B and P curves shows some interesting results. ($B = \int_0^\infty i_2^2 dt$, $P = \int_0^\infty i_1 i_2 dt$, where i_1, i_2 are currents in the primary and secondary, and the functions are plotted as ordinates with the difference of the natural frequencies of the two circuits as abscissæ). The curves show a striking resemblance to the variation of absorption and the square of the refractive index of a dispersing medium near an absorption line. This is not surprising when it is remembered that similar phenomena take place in the optical analogy in so far as energy is absorbed from light-waves travelling through a medium having one or more natural frequencies. Another interesting analogy is to be found in the change with frequency of the motional resistance and reactance of a telephone receiver as found by Wien, and lately investigated in more detail by Kennelly. The simple forms found for the B and P functions enable us to obtain a series of interesting properties of and relations between these functions. Both functions contain a constant factor which is immaterial as far as the functional relation is concerned with regard to the amount of detuning ($\omega_2 - \omega_1$). Omitting these factors, we have $B_1 = (\alpha_1 + \alpha_2)/[(\omega_1 - \omega_2)^2 + (\alpha_1 + \alpha_2)^2]$, and $P_1 = (\omega_1 - \omega_2)/[(\omega_1 - \omega_2)^2 + (\alpha_1 + \alpha_2)^2]$, where α_1, α_2 are the damping factors of the primary and secondary respectively. Combining these, we get $P_1 + iB_1 = 1/[(\omega_1 - \omega_2) - i(\alpha_1 + \alpha_2)]$, subject to the condition that both P_1 and B_1 are real. From these results the following properties may easily be deduced: The breadth of the B_1 curve at a point half-way up the height of its maximum is equal to twice the sum of the damping factors, and the difference of the abscissæ of the maximum and minimum of the curve P_1 is equal to the same quantity. The curves when superposed cut at a point half-way up the height of the maximum of B_1, and this point is the maximum of P_1, and also a point of inflection of B_1.

A number of other relations are also given. A. W.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1544. *Method of Measuring the Capacity of a Gold-Leaf Electroscope.* **A. T. Mukerjee.** (Phil. Mag. 38. pp. 245–256, Aug., 1919.)—The arrangements for using a Dolezalek electrometer for accurate work, devised by V. H. Jackson and the author (see J.A.S.B. Vol. X. No. 6. 1914), have made it possible to develop a quick and very accurate method of measuring capacities of the order of a few cm. only, such as those of gold-leaf electroscopes. Using a standardised (Gerdien) sliding condenser, the absolute value of the capacity of the quadrant system, including a specially designed connector, is first determined by the method of mixtures. The gold-leaf system of the electroscope is then charged to a known voltage, adjusted so that when the charge is shared with the quadrant system the first potential, as measured by the electrometer, is not far from one volt. As the capacity of the quadrant

system can be varied by the sliding condenser, the capacity of the electroscope can be measured at different voltages. There is a slight, but definite, increase of capacity with voltage.

The method is compared with those of L. Cooke [Phil. Mag. 6, p. 410, 1903], and T. Barratt [Abs. 812 (1916)]. The capacity of a small β-ray electroscope charged to about 100 volts has been measured by the three methods, with the following results: Present method $0{\cdot}78 \pm 0{\cdot}01$; L. Cooke's method, as improved by the author, $0{\cdot}75 \pm 0{\cdot}01$; Barratt's method, $0{\cdot}73 \pm 0{\cdot}03$ e.s. unit.

A. B. W.

1545. *The Solution of Circuit Problems.* **T. C. Fry.** (Phys. Rev. 14. pp. 115–136, Aug., 1919.)—*Circuit theory; current in any network; expansion of fundamental integral* in Bessel's series. This is treated quite fully, and is shown to be applicable to circuits with either lumped or distributed impedances. If the upper limit for the roots of the equation for the impedance function is known, the problem may be reduced to the expansion of a function in a Fourier series. By this method, the principal difficulties of computation are included in those processes which can be mechanically performed. This method is, therefore, a valuable addition to those commonly used in the solution of problems relating to complicated circuits.

Circuit theory; current in any network; expansion of fundamental integral. Summary of treatment (1) using Heaviside-Carson expansion, and (2) using Taylor's series, with a discussion of the limitations of each method.

Integral of $e^{in(t-\lambda)}dn/Z(in)$ *from* $-\infty$ *to* $+\infty$ *; expansion in Bessel's series.* Treated quite fully, especially in relation to circuit theory.

Telegrapher's equation; solution by expansion of an integral in Bessel's series. This is treated quite fully, with simple examples. AUTHOR.

1546. *Current–Voltage Characteristics of High-Voltage Thermionic Rectifiers.* **C. L. Fortescue.** (Phys. Soc., Proc. 31. pp. 319–336; Disc., 336–337, Aug., 1919.)—The paper refers to the use of high-voltage thermionic tubes for the production of high-voltage steady current from an a.c. supply. The subject is approached from the designer's standpoint. Curves and approximate methods of calculating them are given from which the best combination of electron current and alternating supply voltage can be determined for any prescribed conditions. Further, the curves allow of the essentials of the specification of the rectifiers and transformer being ascertained, and a formula is given for the capacity of the smoothing condenser required to maintain the steady supply voltage within any assigned limits. Finally, correction curves are added by means of which more exact results can be obtained from the approximate curves given in the first instance. AUTHOR.

1547. *The Use of the Triode Valve in Maintaining the Vibration of a Tuning-Fork.* **W. H. Eccles.** (Phys. Soc., Proc. 31. p. 269 with Disc., Aug., 1919.)—In the form described, two electromagnets act upon the prongs, and the windings of one magnet are in the grid circuit; those of the other magnet are in the plate circuit of the tube. When the fork is in motion the e.m.f. induced in the grid magnet controls the current flowing in the plate circuit and its magnet, with the result that the motion is sustained.

By increasing the distances between the poles of each magnet and the prong confronting it, the apparatus may be adjusted so that the fork is just not maintained in oscillation. In this condition the arrival of a train of sound-waves of exactly the right frequency to produce resonance causes the fork to start into vibration. The instrument is then a tuned relay. A large

fraction of a minute is required in some adjustments to provoke the full response. AUTHOR.

1548. *Electrometer Design.* **E. Schreiber.** (Ann. d. Physik, 59. 5. pp. 425–454, Aug. 5, 1919.)—Describes experiments on various modifications in the design of the Dolezalek electrometer, including needle design. J. W. T. W.

1549. *New Sensitive Quadrant Electrometer.* **A. H. Compton** and **K. T. Compton.** (Phys. Rev. 14. pp. 85–98, Aug., 1919.)—

New quadrant electrometer of high sensitivity, with tilted needle and movable quadrants. *Principle.* If the needle is given a slight tilt about its long axis and one pair of quadrants is raised or lowered a small distance with respect to the other pair, electrical control forces are set up which add to or substract from the restoring torque from the suspension. *The theory* of these forces is discussed, the equation giving the sensitiveness in terms of the potential of the needle and the geometrical arrangement of the quadrants is derived; the method of utilising electrostatic control to the best advantage is also described. *Advantages:* High sensitivity, nearly independent of the deflection, and quick adjustment of sensitivity through a great range. *Results.* By using a small needle, 4·5 mm. in radius, with a slight tilt, sensitivities as high as 60,000 mm. per volt have been obtained. Adjustments are difficult at these extreme sensitivities, but the electrometer can usually be used up to 15,000 mm. per volt without undue trouble. Practical suggestions are given regarding needles, suspensions and mirrors.

Quadrant electrometer: needles of mica or aluminium. Technique. AUTHOR.

1550. *Six-String Einthoven Galvanometer.* (Engineering, 108. p. 255, Aug. 22, 1919.)—The six-string galvanometer here described is made by the Cambridge Scientific Instrument Co. and was especially designed for measuring time-signals, sound-waves, etc. The galvanometer may be placed at a central station which is connected by cables to the six coastal stations. These receive the impulses of a disturbance somewhere out at sea, and convey them to the galvanometer which records them photographically on a moving film. The six stations may be at different distances from the source of disturbance, and in such case the six strings of the galvanometer (each connected to its own station) will be deflected at correspondingly different instants, and from these intervals the source can be located with respect to the station. E. H. B.

1551. *Variable Capacity for use with Quadrant Electrometers.* **H. Clark.** (Le Radium, 11. pp. 235–236, June, 1919.)—The author describes a variable condenser for use in electrometer measurements. With this instrument he claims an accuracy of 0·1%. A. B. W.

1552. *Apparatus for High-frequency Measurements.* **E. Nesper** and **P. Floch.** (Phys. Zeits. 20. pp. 371–375, Aug. 15, 1919.)—Describes, with the aid of several diagrams and photographs, a vacuum tube arrangement capable of being used for many purposes, including wave-length measurements, antenna and coil damping factors, damping due to condensers and insulating material, capacity and self-induction measurements. The arrangement can also be used for wireless transmission and reception. A. W.

ALTERNATING CURRENTS AND MAGNETISM.

1553. *Precision Measurements at Radio Frequencies.* **J. H. Dellinger.** (Phys. Rev. 14. pp. 181–183, Aug., 1919. Abstract of paper read before the Am. Phys. Soc., April, 1919.)—This paper gives a *résumé* of the work done by the Bureau of Standards since March, 1918, in improving the methods for accurate measurement of inductance, capacity, power-factor, resistance, etc., at radio frequencies, in the design of new wave-meters, phase-meters and decremeters, in the use of the kathode-ray oscillograph, and in the measurement of the intensity of signals in a telephone receiver. The crystal detector has been thoroughly investigated, and means devised for improving its constancy. A large amount of work has also been done on the vacuum tube as a generator of oscillations, as a detector and as an amplifier. A. W

1554. *Interferometry of Rapidly Alternating Currents.* **C. Barus.** (Nat. Acad. Sci., Proc. 5. pp. 331–340, Aug., 1919.)—Describes experiments with an improved form of the interferometer previously described [see Abs. 1187 (1919)] on circuits of different inductance and capacity characteristics.
J. W. T. W.

1555. *Variation of Physical Properties of Iron Alloys with Composition and Treatment.* **E. Gumlich** and **P. Goerens.** (Elekt. Zeits. 40. pp. 312–315, June 26; 325–328, July 3; 334–336, July 10; 348–350, July 17, and pp. 361–363, July 24, 1919.)—This paper has already appeared in a condensed form [see Abs. 210 (1919)]; the present paper may be consulted for a more detailed description of the work amplified by the results of micrographic research. G. E. A.

1556. *The Corbino-Effect in Weak Magnetic Fields.* **L. Puccianti.** (N. Cimento, 16. pp. 97–104, Sept.–Oct., 1918.)—Applications of the "double induction-balance" [Abs. 635 (1919)]. The Corbino-effect increases a little more rapidly than the strength of the field, in fields of some hundredths of a gauss. The same phenomenon seems to be presented but in diminishing degree until the field attains a strength of 1000 gauss, after which we have the opposite result as shown by Adams and Chapman. A. D.

1557. *Magnetic Variations of Resistance and Diminution of the Hall Coefficient with Increase of Field.* **O. M. Corbino.** (N. Cimento, 16. pp. 185–196, Nov.–Dec., 1918.)—Develops equations from which may be deduced the number of positive and of negative ions and the mobility of each in metallic conduction, and which lead to a relation between the variations of the Hall coefficient with fields of varying intensity and the corresponding variations of the conductivity. A. D.

1558. *The Magnetic Properties of Varieties of Magnetite.* **E. Wilson** and **E. F. Herroun.** (Phys. Soc., Proc. 31. pp. 299–315; Disc., 315–318, Aug., 1919.)—The magnetic properties of certain varieties of magnetite as exhibited by crystallised, compact or massive specimens and detached particles have been examined. In each case the susceptibility has been found to vary with the magnitude of the magnetising force after the manner of iron, the relative variation being much more pronounced in the case of those specimens having the higher susceptibility. The max. susceptibility in the specimens examined occurs at a force ranging from 13 c.g.s. units in the crystal to 368, its magnitude varying from 3·12 to 0·127 c.g.s. units.

The effect of heating has been greatly to increase susceptibility in some cases and in others a negative effect has been produced. In the case of a specimen of Penryn magnetite, the large increase in the susceptibility was traced to the conversion of ferrous carbonate and ferric oxide into magnetite.

As bearing upon the intensity of magnetisation of magnetite in a natural state, it may be mentioned this specimen of Cornish magnetite acquired an intensity of 1·48 c.g.s. units on cooling in the earth's field from 1000° C., whereas in the cold before heating such an intensity required a field of 95 c.g.s. units to impart the same degree of retained magnetisation.

Very high susceptibility in magnetite is never associated with high coercive force or retained magnetisation, the greatest values for the latter being exhibited by specimens having an intermediate value of susceptibility of the order of 0·3 or 0·4. Lower susceptibility may be associated with high coercive force, but naturally the retained magnetisation is not very great, owing to the lower maximum of induced magnetisation. AUTHORS.

1559. *On the Measurement of Small Susceptibilities by a Portable Instrument.* **E. Wilson.** (Phys. Soc., Proc. 31. pp. 338–346 ; Disc., 346, Aug., 1919.)—A horizontal beam is supported by a phosphor-bronze strip attached to a torsion head. The specimen is held in a grip at one end of the beam, and is counterpoised by a sliding weight. The specimen hangs between pole-pieces which are fixed to the base of the instrument. The magnet consists of two rings of tungsten steel, capable of rotation in a horizontal plane about an axis coinciding with the specimen. Each ring is magnetised with north and south poles at opposite ends of a diameter. By varying the relative azimuths of the rings the field between the pole-pieces can be varied. The method of test consists of turning the torsion head until the specimen just breaks away from the field between the poles. If the torsion angle be θ and the volume of the specimen be V, the susceptibility K is given by $K = C\theta/H^2V$, where H is the intensity of the field and C is a constant. AUTHOR.

1560. *Magnetic Storm of August* 11–12, 1919. **C. Chree.** (Nature, 103. pp. 505–506, Aug. 28, 1919.)—A "sudden commencement" was recorded at Kew Observatory at about 7h. G.M.T. of Aug. 11th. During the storm the range in declination was 2° 5′, and in vertical force 935γ. The horizontal force trace twice left the sheet, so that the range shown, 840γ, may have been considerably exceeded. The commencing movements were of an unusual character. There was at the start a rapid rise of horizontal force amounting to 75γ. In less than a minute the movement was reversed and a fall exceeding 450γ in 12 mins. took the trace off the sheet. H remained depressed for nearly 1½ hours, but then for a few minutes it was above the normal value. After this another large fall again carried the trace off the sheet from 9 h. 15 m. to 9 h. 25 m. The disturbance in vertical force, though exceptionally large, was of the usual type. The ranges recorded on this occasion have seldom been approached at Kew.

A. C. Mitchell. (Nature, 103. p. 506, Aug. 28, 1919.)—At Eskdalemuir the "sudden commencement" was of unusual type, and its study was complicated by the fact that a minor disturbance began on the north component 32 minutes before the other components experienced the sudden commencement of the storm. When this occurred, at 6 h. 58 m., the north-component light spot was sent completely off the sheet with such rapidity that it is impossible to say whether the change was one of increase or decrease. There

is, however, distinct evidence that this component was below normal 1 minute after the sudden commencement. The changes of vertical force during the early part of the storm, which are here detailed, were also of an unusual character. The first maximum was recorded at 7h. 13m. (+44γ) while the first maximum in the west component was at 7h. 10m. (+188γ). The disturbance was also peculiar in the suddenness with which it ended at about 19h. on the 12th, and in the magnetically quiet conditions which succeeded it. J. S. Dr.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

1561. *The Radiator Type of X-ray Tube.* **W. D. Coolidge.** (Am. J. of Roentgenology, 6. pp. 175–179, April, 1919.)—The radiator type of tube has already been described [Abs. 415 (1918)]. Owing to the fact that the tube has recently become generally available for use on existing standard generating outfits, the present amplification will be useful. This tube will do better diagnostic work on any generating outfit than will the earlier forms of hot-kathode tube with the solid tungsten target. The radiator tubes operate satisfactorily on the transformer, the interrupterless outfit, and the induction coil, and are hence generally applicable to diagnostic work. With the induction coil it renders a valve tube unnecessary. With the interrupterless machine, it offers the advantage that it is not injured by a faulty setting of the mechanical rectifier. With every current-source it permits of the intermittent use of more energy than could in practice safely be carried by a tube with a solid tungsten target and the same size of focal spot. It is not, in its present form, adapted to therapeutic work, for, with the continuous operation, it will carry less than one-fourth as much energy as the 7-in. hot-kathode tube with solid tungsten target. For a given voltage the current-carrying capacity of a tube of the radiator type is a very definite quantity. This is due to the fact that the target of the tube cools so rapidly between exposures that every exposure is started with a relatively cold target. What can be done with the tube then, in radiographic work depends but little on its past history. The current-carrying capacity is the same for alternating as it is for rectified current, as the tube will safely rectify any current which does not damage the focal spot. When used where it has to rectify its own current, it shows its greatest superiority over the tube with solid tungsten target used under the same conditions: experimental data to illustrate this latter point are given. When operating the tube on an interrupterless machine it is imperative, for satisfactory diagnostic work, that a voltage control of the auto-transformer type be employed. The results obtained should be better than with the solid tungsten target tube; for in general, for a given amount of energy, a smaller focal spot can be used in the radiator tube. The tube also offers this additional advantage for use in this way: that a faulty setting of the rectifying device, resulting perhaps in sufficient inverse current to ruin the tube with the solid tungsten target, will not injure the radiator tube. The use of low milliamperage, the shield for the radiator tube, and the effect of the radiator tube on the design of generating apparatus are also discussed.

Substitute for the platinum anode. As the result of much research it has been found possible to produce an entirely satisfactory substitute for the platinum anode, consisting of an alloy of iron and nickel covered with copper. A. E. G.

1562. *Use and Abuse of Röntgen-ray Tubes.* **C. N. Moore.** (Am. J. of Roentgenology, 5. pp. 529–531, Nov., 1918. Paper read before the Am. Roentgen

Ray Soc., Sept., 1918.)—The all-tungsten target tube in the 7-in. bulb is intended to be operated under the following conditions: (1) With voltages as high as that corresponding to a 10-in. parallel spark-gap between points, and with currents depending upon conditions explained later, and (2) upon apparatus delivering current to the tube. The energy that such a tube will carry may be considered as the product of the milliamperage *times* the potential (spark-gap). Once the target design is fixed, the allowable energy input is determined principally by four things: (1) the target material, (2) the area of the focal spot, (3) the time during which the energy is applied, and (4) the temperature of the target at the time the energy is applied. Of the energy applied to the focal spot approximately 99·8 % is converted into heat, so that the question of the allowable energy input is really a question of the rapidity with which heat can be removed from the focal spot, and of the melting-point of the target material. Probably the worst abuse of the X-ray tube is due to a lack of consideration of the fact that tungsten has a definite melting-point. Present practice is resulting in repeated melting of the focal spot in many tubes. The molten tungsten vaporises rapidly in an evacuated space and deposits a thin film over the active hemisphere. This mirror-like metal deposit on the inside of the glass should not be confused with the violet colouration which always results when the particular kind of glass used in these bulbs is subjected to prolonged exposure to X-rays. This violet colour is due to some change taking place within the glass and is perfectly harmless. The film of tungsten exerts no appreciable filtering effect upon the X-ray, but it does disturb the electrical conditions within the tube. The metal of the tube stand is usually earthed, and the large number of punctured bulbs would be greatly reduced if the practice of blackening bulbs were discontinued.

For continuous operations in Röntgenotherapy the limiting feature is not so much the target as the glass of the bulb. It is possible to get the body of the target so hot that heat radiated from it may cause gas to be driven out of the glass, or may even melt the glass. Adequate cooling of the bulb is therefore necessary to prevent this. The tube with solid tungsten target is not designed to operate directly from the terminals of a high-tension transformer without the interposition of a suitable rectifying device; or from the terminals of a coil without the use of valve tubes. Operation under these conditions constitutes one of the worst abuses. Again, it is a question of the temperature of the focal spot. Tungsten at a temperature of about 2000° C. begins to emit electrons at an appreciable rate. As a consequence, if a source of alternating potential is applied to the terminals of a tube with the focal spot or any point in the focal spot, at or above this temperature, inverse current will pass through the tube. This inverse current may focus on the glass in the kathode stem, causing cracking and the emission of gas, or it may focus on the glass of the bulb directly below the kathode. It is customary to speak of the tube being punctured by inverse at this point. What really happens is that the inverse current heats the glass locally so that it actually melts, or else sets up strains so that the glass cracks during this or some subsequent operations. After cracking, the air rushes in and the electric current travelling along the air current gives the impression that a spark was the cause of the puncture. The presence of inverse current is always indicated by green fluorescence at the kathode end of the tube.

The radiator type of tube is adapted to diagnostic use only, and the allowable energy input is limited to that corresponding to 10 milliamps. at a 5-in. parallel spark-gap. For continuous operations in fluoroscopy the current is limited to 5 milliamps. It is not suitable for therapy for the reason that it

has not been designed to operate at voltages used in such work, and because it will not carry continuously more than ¼ kilowatt. The radiator-type tube is so designed that it will rectify its own current, and can therefore be operated directly from the terminals of a high-tension transformer or a coil. A. E. G.

1563. *Physical Investigation on Tubes and Accessories.* **W. D. Coolidge.** (Am. J. of Roentgenology, 4. pp. 3–8, Feb., 1919.)—The production and maintenance of very high vacua is first discussed, and a description with drawing of Langmuir's new form of mercury-vapour pump—the so-called condensation pump—is given. It was found that the introduction of metallic thorium or zirconium powder enables the bulb of the tube to be heated to collapsing point without troublesome impairment of the vacuum. It seems most probable that these rare-earth metals help in maintaining a vacuum by reacting with the gases given off from the glass, and that the solid compounds so formed have an exceedingly low decomposition pressure, even at the temperature at which the glass softens. Another method which has been tried with success is to make the tube entirely of fused quartz. The use of purified nitrogen gas as the residual in the tube also yields good results.

To get the greatest possible X-ray intensity from a focal spot of given size the energy delivered to the focal spot must be as uniformly distributed over it as possible. The size of the focal spot and the energy distribution are determined by the kathode design, the size and shape of the anode, the distance between anode and kathode, and the size of the bulb. Widely different focal spots can be produced with the same design of filament spiral, the same design of anode, the same size of bulb, and the same distance between filament spiral and anode by merely changing the design of the focusing device. The problem of getting the best focal spot of a given size for a given size of bulb finally resolves itself into making up an experimental tube in which the distance between anode and filament spiral can be varied at will, and in which the position of the filament with respect to the focusing device can also be varied at will. The construction of such a tube is described and illustrated. The problem of the metal tube is also discussed at some length. A. E. G.

1564. *Apparatus for Portable Radiography.* **W. D. Coolidge.** (Am. J. of Roentgenology, 6. pp. 3–30, July, 1919.)—A general discussion is given of the problem and also a description of an experimental portable apparatus, together with the considerations which have led to its present form.

The following general points are dealt with: Weight and size limitations; capability of standing mechanical abuse; water-proofness; amount of electric energy available; best voltage for X-ray tube; size of focal spot in X-ray tube; rigid tube support; the low-tension winding of transformer or coil should be insulated from the ground; sufficient range of electrical control to adapt outfit to operation on all lighting circuits; quietness of both mechanical and electrical operation; sufficient mechanical flexibility in the tube-holding mechanism; ship-shape condition of high-tension circuit; current-limiting device; X-ray protection; stereoscopic tube-shift; connections for low-tension circuit; precautions necessary to guard against breakage. The portable outfit is discussed; it is also fully illustrated by diagrammatic and photographic representations of parts. A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1565. *Relation between the Atomic Weights of the Chemical Elements, their Densities and Thermal Properties.* II. **K. Fehrle.** (Phys. Zeits. 20. pp. 330–332, July 15, 1919.)—In an earlier paper [see Abst. 1142 (1918)] the author has deduced a formula for the heat of combination of two elements, this formula involving the atomic weights and densities of the elements. Further evidence in support of this formula is now published. A. B. W.

1566. *Are the Divergencies of the Atomic Weights from Integers explainable by Isotopy?* **O. Stern** and **M. Volmer.** (Ann. d. Physik, 59. 3. pp. 225–238, July 4, 1919.)—In order to ascertain if the difference between 1 : 16 and the actual ratio of the atomic weights of hydrogen and oxygen (1·008 : 16) depends on the isotopy of these elements, each gas was passed through a porous porcelain tube so that most of it diffused away; the residue (one-thirtieth) was then burnt to form water, the density of which was determined. Since the molecular volumes of isotopes are equal and their molecular weights different, their densities also are different. In the case of hydrogen the change in the density of the water obtained in this way is not more than one-seven hundredth, and in that of oxygen less than one-one hundred and eightieth what it should be on the assumption of isotopy. The latter is hence insufficient to explain the divergence of the atomic weight ratio from 1 : 16, and it is shown that any theory of atomic structure founded on Prout's hypothesis must explain the divergences of atomic weights from whole numbers by energy differences. T. H. P.

1567. *Electrical Conductivity of Elements conditioned by the Presence of Isotopes?* **F. H. Loring.** (Chem. News, 119. pp. 14–16, July 11, and pp. 199–200, Oct. 31, 1919.)—On the same view that the conductivity of elements is modified profoundly by charges of temperature, the author raises the question as to whether or not it may be conditioned by some other cause. For example, if it be assumed that silver is made up of isotopes having atomic masses 107 and 111 in the respective proportions of 7 to 2, which gives the mean atomic mass of 107·888, then there would be 22·2% of the higher-mass atoms calculated by taking the relative numbers 7 and 2, or 22·8 % by taking corresponding aggregates. Bromine is taken as the other extreme, and from the two examples the author indicates that the greater the percentage of higher-atomic-mass isotopes the lower the electrical conductivity, since silver is the best conductor and bromine is an insulator. The author gives a table in which he points out that the rule holds good for the elements having isotopes of such values and in such relative proportions as to make up the present accepted atomic masses.

The paper is highly speculative in character, as the author himself realises, urging that "these speculations are made with a view to finding some new road for experimental investigation." A. B. W.

1568. *Physical Constants of Chlorine under the Action of Light.* **A. Campetti.** (N. Cimento, 17. pp. 143–158, April–May–June, 1919.)—

Experiment shows that the internal friction and the thermal conductivity of chlorine are not appreciably modified by the light from an arc lamp passed through a dilute solution of copper sulphate to free it from most of the less refrangible radiations. The same is, contrary to the conclusions of Trautz (Zeits. Elektrochem. 18. p. 513, 1912), most probably the case with the thermal capacity, that is, the specific heat at constant volume, of the gas. The value of $\eta \times 10^7$ found for chlorine is 1328 at 15°, while the thermal conductivity of chlorine is about 0·8 times that of air. T. H. P.

1569. *Non-Allotropic Nature of the A2 Transformation in Iron.* **K. Honda.** (Iron and Steel Inst., J. 99. pp. 457–464; Corres., 465–467, 1919.)—Considers the nature of the transformations in iron and steel and concludes that, in the case of pure iron, of the three transformations A2, A3 and A4, the two latter are allotropic whilst the first cannot properly be called an allotropic change of phase. In the case of carbon steels there are two further transformations, A0 and A1. The latter is a change of phase, whilst the former is a change having the same nature as the A2 transformation. The A0 and A2 transformations are internal changes extending from the critical temperature to the lowest; every stage of these changes is a definite function of temperature. From the standpoint of the molecular theory of magnetism, these transformations may be regarded as processes in which the molecules acquire rotational energy about their magnetic axes. C. O. B.

1570. *Influence of Manganese on the Physical Properties of Carbon Steels.* **T. Matsushita.** (Tôhoku Univ., Sci. Reports, 8. pp. 79–88, Aug., 1919.)—Gives the results of an investigation of the properties of a series of steels low in carbon (0·2 %) and containing from 0·11 to 9·80 % Mn. The thermal and electrical conductivity tests show that the changes in the two conductivities, varying with the amount of Mn are similar to each other and the ratio of the two conductivities for constant content of Mn is almost constant, its mean being $1{\cdot}92 \times 10^{-6}$. By adding manganese to iron, the two conductivities decrease, at first very rapidly, pass a small minimum at 0·7 and a maximum at 1·0 %. This shows that to get a good, conducting steel for heat and for electricity the Mn must be kept low and, by deduction from the electron-theory, that an alloy steel having a high thermal conductivity and a high electrical resistance cannot exist. In the case of the moduli of elasticity and rigidity the samples show first a decrease with a minimum at 0·6, then a maximum at 1·6 % Mn; after this they decrease and then again increase. Results are also given for the thermal expansion at high temperatures and for the intensity of magnetisation. The general results of the investigation of manganese steel are compared with results obtained in the case of tungsten steels. C. O. B.

1571. *Some Physical Constants of Tungsten Steels.* **K. Honda** and **T. Matsushita.** (Tôhoku Univ., Sci. Reports, 8. pp. 89–98, Aug., 1919.)—An investigation of the thermal and electrical conductivities, the moduli of elasticity and rigidity, and the linear expansion coefficients of some tungsten steels. Two series with W-content varying up to 25 % were studied, the one containing 0·3 % C and the other 0·6 % C. They were examined (*a*) under normal structure, annealed at 900° C. and slowly cooled; (*b*) heated above 1100° C. and cooled quickly. With normal structure the ratio of the two conductivities is independent of the W-content. The conductivities decrease rapidly at first with the addition of W, reach a minimum,

then rise to a maximum and finally decrease. Under condition (*b*) there is a continual decrease with the addition of W. The effects are accounted for by alteration in structural composition, the occurrence of the minimum and maximum being attributed to the presence of the double carbide [4 Fe_3 C. WC] and the subsequent diminution to the presence of tungstide (Fe_2 W). The two elasticity–concentration curves are very similar to the inverted conductivity–concentration curves. The coefficients of expansion–concentration curves at 100° and 500° C. are similar to the conductivity–concentration curves. The curves at 850° possess no maximum and minimum values, indicating that the double carbide is decomposed into its component carbides. L. L.

1572. *Metallography of Rifle-barrel Steel.* **G. F. Butterworth.** (Am. Inst. Mining Eng., Bull. No. 151. pp. 1107–1111, July, 1919.)—The metallographic structures of rifle barrels [American Practice Abstractor] fall into two groups: (1) rolled barrels produced by hot working in or near the critical range, and (2) "heat-treated" barrels in which the stock, smaller in diam. than the first, is upset to form the breech and then subjected to oil quenching and tempering. Rolled barrels possess the microscopic structure of annealed steel with a network of excess ferrite outlining the grain boundaries, but the grains themselves are sorbitic rather than pearlitic. The effects of rolling above, within and below the critical range (704 — 732° C. in this class of steel containing 0·5 to 0·6 % C. and 1·0 to 1·3 % Mn) on the microstructures are illustrated and discussed. Heat-treated barrels are oil quenched from 816° C. and subsequently tempered at 427° to 648°, the latter being the usual drawing temperature. The resulting structures are sorbitic or sorbito-pearlitic. It is difficult to estimate the degree of tempering from the microstructure, this being best done by macroscopic examination of specimens etched for 45 secs. in a 5 % solution of picric acid in alcohol, since between the limits of temperature mentioned the colour of the specimen becomes lighter as the tempering temperature is increased.

Defects due to burning, phosphide segregation and slag enclosures are also illustrated. F. C. A. H. L

1573. *Erosion Tests on Rifle Barrels.* **A. E. Ellis.** (Am. Inst. Mining Eng., Bull. No. 151. pp. 1073–1077, July, 1919.)—In order to throw some light on the differences of opinion among rifle experts as to the bearing of composition, heat treatment, structure and physical properties of the steel on the life of a rifle barrel the author has carried out a series of tests with steel to the U. S. A. Government specification which is: carbon, 0·50/0·6 %; silicon, below 0·25 %; sulphur, below 0·06 %; phosphorus, below 0·08 %; manganese, 1·00 to 1·29 %; yield stress, over 33·5 tons per sq. in.; ultimate stress, 49 tons per square in.; elongation, over 20 % and contraction over 45 %. These properties are obtained by rolling or heat-treatment [see preceding Abs.]. A heat-treated barrel, a barrel rolled at 732° C. and a barrel rolled at 648° C. were subjected to 13,000-round firing tests and subsequently tested for accuracy and erosion. The results, in the opinion of the author, prove the superiority of the heat-treated barrel. F. C. A. H. L.

1574. *Constitution and Metallography of Aluminium and its Light Alloys with Copper and Magnesium.* **P. D. Merica, R. G. Waltenberg** and **J. R., Freeman, Jr.** (Am. Inst. Mining Eng., Bull. No. 151. pp. 1031–1049, July

1919. Bureau of Standards, Bull. 15. pp. 1–119 [Sci. Papers, No. 337]. Washington, 1919.)—The authors recommend a 0·1 % solution of NaOH containing 10 % alcohol as a etching reagent for aluminium. This does not develop the grain boundaries, but brings out well any other constituents present. The influence of small quantities of Fe and Si on the microstructure of Al is dealt with, and a small portion of the ternary diagram Al-Fe-Si containing large amounts of Al is given. The solubility of the silicon compound present is from 0·12 to 0·20 % at 615° C. At lower temperatures the solubility decreases. Iron as $FeAl_3$ is soluble to less than 0·15 %. $CuAl_2$ present in Cu-Al alloys can be distinguished from $FeAl_3$ by the fact that it is much lighter in colour and does not turn brown on etching for several minutes with 0·1 % NaOH as does $FeAl_3$. The limits of solubility of $CuAl_2$ in Al at various temperatures are given :

Annealing temp.	525°	500°	400°	300° C.
Percentage of Cu.....	4·0	3·1	2·0	1·0

Annealing for 20 hours or 10 days leads to identical results. At 400° C. equilibrium is reached in 30 mins. 1 % Mg does not affect appreciably the solubitity of Al_2Cu in Al. The solubility of Mg_4Al_3 in chill cast Mg-Al alloys after annealing at ascending temperature and then quenching is given as follows :—

Temperature	450°	400°	300° C.
Percentage Mg	12·2 — 13·2	12·2 — 13·2	5·9

A deep-blue constituent is observed in commercial Mg-Al alloys and believed to be Mg_2Si. F. C. T.

1575. *Premature Fractures of Transverse Test-Pieces of Steel.* **Portevin.** (Comptes Rendus, 169. pp. 270–272, Aug. 11, 1919.)—The premature "woody" fractures obtained from transverse test-pieces of steel are shown to be connected with local segregations of sulphides. These are almost always found in that part which has come from the equiaxed crystallisation of the core of the ingot, hardly ever occurring in that from the "basaltic" exterior. To investigate the sulphides on the fracture surface a paste consisting of gelatine, glycerine and water is used as the plastic support for the sensitive silver-bromide emulsion. To reduce such fractures it is suggested (*a*) to reduce to a minimum the evolution of gas during casting, and (*b*) to use as small ingots as possible. [See Abs. 1001 (1918).] F. C. T.

1576. *A Simplification of the Inverse-Rate Method for Thermal Analysis.* **P. D. Merica.** (Bureau of Standards, Bull. 15. pp. 101–104, [Sci. Papers, No. 336], 1919. Am. Inst. Mining Eng., Bull. No. 151. pp. 1021–1023, July, 1919.)—One of the most useful and at the same time least commonly used methods of thermal analysis for the determination of transformations in metals and alloys consists in the recording of the time intervals required for successive increments of temperature-change during heating or cooling, the temperature of the furnace which contains the specimen being altered at a uniform rate. For the measurement of the successive time intervals it is usual to employ a chronograph, the observer subsequently reading the intervals from the record.

To avoid the necessity for an expensive chronograph and to economise time the author recommends the use of two stop-watches. These may con-

veniently be mounted in a small frame to be held in one hand, a finger being placed on each stem. During the "run" the operator sets the potentiometer and marks the instant at which the galvanometer is at zero by pressing the stems of both watches simultaneously, stopping one at the end of the interval which it has measured and starting the other upon its measurement of the next. The interval is read and recorded upon a suitable blank sheet, the hand of this watch returned to its zero position, and the potentiometer set at the next value. The operation is repeated for each successive interval. The intervals so recorded are afterwards plotted directly as a function of the e.m.f. E. G.

1577. *Representation of the Properties of Binary Systems.* **G. Masing.** (Int. Zeits. Metallog. 9. pp. 82–89, March, 1917.)—The study of the dependence of some property (like electric conductivity) upon the proportion of the two components has been fruitful in some cases, but is indefinite in its generality, and there has been much uncritical experimenting. Peculiar curves may be obtained, and the selection of the variables is material. A suitable variable is found in an additive property, such as weight or atomic percentage. Volume percentages are unsuitable because volume changes may occur; when the electric conductivity is observed, the curves would represent, not the relation between conductivity and composition, but between conductivity, composition and specific volume. In the case of alloys two principal cases should be differentiated. The property selected may be an intensity magnitude, independent of the quantity of the phases present; in a mechanical mixture the curves would be a straight line parallel to the axis of concentration. When the property is specific (referred to unit quantity of alloy), the unit must be that employed in plotting the axis of concentration. The specific volume is a function of the weight concentration, but the density is not a function of the volume concentration. Fusion and transition phenomena are considered from this standpoint. H. B.

1578. *Osmotic Pressures Derived from Vapour-Pressure Measurements. I. Aqueous Solutions of Cane-Sugar and Methyl-Glucoside.* **Berkeley, E. G. J Hartley,** and **C. V. Burton.** (Roy. Soc., Phil. Trans. 218. pp. 295–349 May 20, 1919.)—

Part I. *Compressibility.*—A new and improved form of apparatus for measuring the compressibility of liquids is described. The liquid is enclosed in a glass piezometer, with two bulbs instead of one, in order to facilitate control of temperature, the two bulbs leading into a capillary tube below and into a descending capillary at the top. The liquid is enclosed between threads of mercury in the two capillary tubes, and its volume is determined by reading the position of the mercury in the upper capillary through a pair of windows in the compression vessel, and the position of the mercury in the lower capillary (for a series of 5 different pressures, applied and removed slowly) through 5 pairs of windows in the lower part of the compression vessel. Results for various ranges of pressure are given for water at 0° and 30° C, and for solutions of cane-sugar and of α-methyl-glucoside at the same two temperatures.

II. *Vapour-Pressure.*—An improved apparatus for the measurement of vapour-pressure is described, and the various sources of error and corrections are described and discussed. Values are given for the vapour-pressures of aqueous solutions of cane-sugar and for α-methyl-glucoside at 0° and at 30°, together with some values for dilute sulphuric acid at 30° C. The method

adopted in every case was to pass the air successively through the solution and the solvent and then through sulphuric acid to absorb the vapour; this method was found to be quite satisfactory for vapour-pressures as high as 31 mm.

From the vapour-pressures thus measured the osmotic pressures were calculated for cane-sugar and for methyl-glucoside at 0° and at 30° C. The values for 0° C. agreed very closely with the observed values, the max. difference being 0·5 atmo. on pressures up to 135 atmos. It is of interest to note that in the case of α-methyl-glucoside the calculated osmotic pressures for 0° and 30° C. give curves which intersect at about 75 atmos.

T. M. L.

1579. *Reduction of Cryoscopy to the General Laws of Solubility.* **A. Colson.** (Comptes Rendus, 168. pp. 1047–1049, May 26, 1919.)—In order to connect the fundamental cryoscopic laws with his theory of solubility, the author applies his original formula deduced from thermodynamics without involving any hypothesis as to nature of the dissolved state, namely: $425L = T(V + \varepsilon).dp/dT$. Rigidly $V + \varepsilon = U + u$, where U is the final volume of the solution, and u that of the dissolved body. When the solution is very dilute, u is negligible with respect to U, so that $425L = TU.dp/dT$. If the solution is unsaturated with respect to the solute, but deposits crystals of the solvent on cooling, it is itself a saturated solution with respect to the solvent, and if L′ is the heat of solution of a molecule of solvent solidified in the solution at a temperature T, and p the osmotic pressure of the body in solution, then the general formula may be written, $425L' = T(V' + \varepsilon').dp/dT$, V′ being the volume of solution saturated with respect to the solid solvent at T° containing a molecule of the second body. From this formula, applied to dilute solutions, the author deduces the law of Raoult's cryoscopic phenomena.

H. H. Ho.

1580. *Electrometric Titrations, with special reference to the Estimation of Ferrous and Ferric Iron.* **J. C. Hostetter** and **H. S. Roberts.** (Am. Chem. Soc., J. 41. pp. 1337–1357, Sept., 1919.)—The authors have investigated the conditions affecting the accuracy of the electrometric estimation of iron. The principle of the method is to determine the e.m.f. of the combination of a calomel electrode and a platinum electrode dipping into the solution during the titration with potassium dichromate. The curve showing the relation between the e.m.f. and the volume of dichromate used rises sharply at the end point and gives a point of inflection. It is found that the acidity of the solution need not be controlled except within very wide limits, and hydrochloric, sulphuric or hydrofluoric acid, or mixtures of these, may all be used. The method is very accurate, and by means of it percentages of ferrous iron as low as 0·0002 % can be estimated. The method can also be extended to the titration of ferric iron by means of stannous chloride and also of potassium dichromate by titration with stannous chloride. Total ferrous and ferric iron can be estimated by reducing the solution with excess of stannous chloride and then titrating with dichromate. The resulting curve shows two points of inflection, the first indicating when the excess of stannous chloride is used up and the second corresponding with the complete oxidation of the iron. The sensitivity and accuracy of the method make possible the estimation of a few tenths of a milligramme of tin, chromium, ferrous or ferric iron, and probably many other elements, in the presence of large quantities of some other element. It can be used to

determine the "blank" error in the estimation by ordinary titration methods. The time necessary for an estimation is greatly shortened ; for example, the content of ferrous and ferric iron in a silicate can be estimated in 15–30 minutes. T. S. P.

1581. *Electrical Apparatus for use in Electrometric Titration.* **H. S. Roberts.** (Am. Chem. Soc., J. 41. pp. 1358–1362, Sept., 1919.)—A description of two simple and cheap potentiometers which may be used for electrometric titrations such as those described in the preceding Abstract. The scale on the potentiometer is so arranged that the scale readings are always positive, even though the e.m.f. developed by the potentiometer changes from negative to positive as the slider is moved along the scale. T. S. P.

1582. *Phenomenon of Anodic Polarisation.* II. **A. Smits.** K. Akad. Amsterdam, Proc. 21. 10. pp. 1349–1351, 1919.)—An explanation is given of the phenomena described in the author's first communication [compare also Aten, Abs. 882 (1918)]. The explanation is based on the idea that iron in the state of internal equilibrium can only exist in contact with a solution containing practically no ferric ions ; in the presence of ferric ions its potential becomes less negative. When iron, immersed in a solution giving the phenomena in question, is brought into solution anodically, the electrolyte changes in the neighbourhood of the iron, which dissolves exclusively as ferrous ion. During solution the equilibrium of the iron is distributed, as is evidenced by the fact that it becomes less negative during the passage of the current. At the same time the liquid layer in contact with it becomes poorer in ferric ions than the main bulk of the solution. When the current is broken the iron surface is transformed, with fairly great velocity, in the direction of its internal equilibrium, and since it is surrounded by a solution containing fewer ferric ions than the main bulk of solution, the potential of the iron will be more negative than before anodic polarisation. This state lasts only a very short time, however, since ferric ions diffuse into the boundary layer, causing the potential to become less negative and finally to rise to its original value. T. S. P.

1583. *Activities of the Ions of Strong Electrolytes.* **D. A. MacInnes.** (Am. Chem. Soc., J. 41. pp. 1086–1092, July, 1919.)—From theoretical considerations it is shown that, since for the chlorides of the alkali metals and of hydrogen the product of the transport number of the chloride ion and the equivalent conductivity is a constant at a given concentration and temperature, it may be assumed that the activity of the chloride ion in these solutions is also independent of the nature of the univalent positive ion. On this basis the activity coefficients of both ions of hydrochloric acid have been calculated for a series of concentrations ; the potential of the normal hydrogen electrode against the normal calomel electrode has also been calculated, the value $E = 0{\cdot}2829$ volt being obtained. T. H. P.